GENEALOGY OF SEX

THE
AUTHOR
HIS WORK
and
THIS BOOK

"Dr. Thesing is a physician, zoologist and scientific writer of repute, author of numerous biologic works of both general and technical character. He has been director of the scientific division of the great publishing house of Teubner in Leipzig and a co-founder of the widely known periodical *Die Naturwissenschaften*. These qualifications peculiarly fit him to write the present work, which is a panorama of the development and diversifications of the reproductive function in the animal world."

—Journal of the American Medical Association

Publishers' Note

A SHORT TIME AGO a copy of the English edition of this book was sent to this country. Prior to its admission the fact of its impending arrival was called to the attention of the Customs, who were requested to pass upon its admissibility under the provisions of Section 305 of the Tariff Act.* Upon receipt of such request the Customs Bureau issued an official and specific ruling holding that the book was admissible under the above mentioned Act.

That this would be the result was practically a foregone conclusion. To use the language of Judge Woolsey in a famous case, it was to be expected that the book would "be welcomed within our borders."

Both abroad and in this country this work has been recognized not only as a unique and important addition to biological and sociological literature, but also as containing valuable information for the layman, in helping him better to comprehend his own nature, and that of those about him. Press opinions from leading medical, sociological and lay publications appear elsewhere herein.

Our great universities have been quick to realize the stature of the book and it has been recommended for reading at many of our foremost institutions of learning, including Columbia University, Johns Hopkins University and the University of Michigan.

An abiding place among the notable scientific writings of our time would seem assured for this pioneering work.

THE PUBLISHERS

* This section (1305, U. S. Code) deals with the exclusion from this country of imported matter deemed obscene, or otherwise objectionable. It is substantially the same as corresponding sections in the Postal Law and in the Obscenity Statutes of the various States.

GENEALOGY OF SEX

Sex in its myriad forms, from the one-celled animal to the human being

By CURT THESING, M.D.

Translated from the German by
EDEN and CEDAR PAUL

Introduction to the American edition by
SMITH ELY JELLIFFE, M.D.

Consulting Neurologist, Manhattan State Hospital and Kings Park State Hospital; Practising Physician; erstwhile Clinical Professor of Mental Diseases, Fordham University; also Adjunct Professor of Diseases of the Mind and Nervous System, Post Graduate Hospital and Medical School; Managing Editor, The Journal of Nervous and Mental Disease.

THE AUTHOR

Dr. Curt Thesing received his training in biology and medicine in Marburg and Munich. He has held posts at the Statione Zoologica in Naples and at the Zoological Institute of the University of Berlin. While in the latter position he was also Director of the Biological Department of the Urania, as well as Lecturer at the Humboldt Academy. He has conducted extensive researches in the field of heredity.

In 1907 Dr. Thesing became Director of the scientific division of the publishing house of B.G. Teubner in Leipzig; later becoming co-founder of the periodical "The Natural Sciences," and also publishing the scientific journal "Nature."

In the course of his researches he has several times gone on long expeditions, chiefly to Northern Africa.

His works include "Propagation and Heredity," "Biological Inroads," "Experimental Biology," "Laws of Propagation," as well as numerous technical writings in the field of biology.

NEW YORK
EMERSON BOOKS, INC.
1937

COPYRIGHT 1934, 1937 BY EMERSON BOOKS, INC.

All rights reserved. This book, or parts, thereof, must not be reproduced or translated in any form or language without permission in writing from the publishers.

SECOND AMERICAN EDITION
With New Matter

ACTURED IN THE UNITED STATES OF AMERICA

IN RECENT YEARS the courts of our country have wisely and generously pronounced in favor of rational sex education. The decision of Federal Judge John M. Woolsey in the United States District Court, in the Stopes case, and the decision of Federal Judge Augustus N. Hand, in the United States Circuit Court of Appeals, in the Dennett case, are outstanding examples of such pronouncements.

Federal Judge Hand, in the course of rendering his opinion, found occasion to declare:

> "*. . . The old theory that information about sex matters should be left to chance has greatly changed . . . It may reasonably be thought that accurate information, rather than mystery and curiosity, is better in the long run.*"

Turn to next page for press opinions.

PRESS OPINIONS
OF THE FIRST AMERICAN EDITION

"The story of the many interesting and curious developments of sexual processes and mating behavior that have been evolved in various groups of animals from the lowest to the highest and from the simple to the complex. Some of these widely divergent and curious accomplishments of the sexual instinct serve to illumine the obscurer aspects of sexual behavior and abnormalities of sexual development in man. . . . An interesting compilation of sex lore.

". . . Dr. Thesing is a physician, zoologist and scientific writer of repute, author of numerous biologic works of both general and technical character."

—*Journal of the American Medical Association*

"This book furnishes the reader with a wealth of information concerning the origin and development of the sexual impulse. The sub-title 'Sex in its myriad forms, from the one-celled animal to the human being,' aptly describes the scope of the biologic field discussed.

"The sex urge or the blind forces of reproductive impulses have for the most part been shrouded in the dark cloak of ignorance. Ignorance and superstition are some of the chief sources for blunders and misunderstandings. Attempts by the many to better understand sex urges oftentimes find themselves swayed by the vagaries of would-be informants. This book, however, starting, as it does, with the life of the lowest order and developing in scientific chronological order the origin of sexual impulses in an incredible diversity of forms will give the reader a background for better understanding of this topic.

"The book has been written in easily understood language. It should prove of value to the man of science as reference material; it should lead to better comprehension of man's nature for the layman."

—*Journal of Public Health Reviews*
(*University of Michigan*)

. . . "The diverse forms in which the mechanics of the sexual impulse are depicted, and the broad basis of biological knowledge on which this kaleidoscopic array of behaviorisms is drawn, make together a work of comprehensive reference value for the student and layman alike.

"It is a worthy addition to the large body of scientific investigation concerning the problems of man's origins and the sexual aspects of his evolutionary development which has formed one of the most enlightened marks of our time." —*Journal of Nervous and Mental Disease*

"Unsurpassed as a lucid and scientific introduction to the biology, psychology and sociology of sex and the love emotions." —*Dr. Harry Elmer Barnes in the New York World-Telegram*

"This most excellent book follows its title closely. It traces the origin and growth of the component factors of the sex impulse from their earliest appearances in unicellular animals to their final expression in man. Each point is so thoroughly elucidated by innumerable explanations of the habits of lower animals that the book is encyclopedic with reference to sexual habits and customs throughout the animal kingdom. Nevertheless, the author has carefully held to the main thread of his story —the development of the sexual instinct in human beings. . . . —*Mental Hygiene*

"Among the endless stream of books on sex that is pouring from the press here is one that stands out, both by reason of its subject matter and its scholarly treatment. Dr. Thesing has confined himself to a study of the sexual impulse in the myriad ways in which it manifests itself, from the protozoa up to man. . . .

"Not only the student but the general reader will find in this book a great deal of authentic information, which is necessary to an adequate understanding of the complicated sexual life of modern man. The copious illustrations are not the least of its helpful features. . . ."

—*The Psychoanalytic Review*

"A biological panorama of sex in the animal world, examining in detail the methods whereby life perpetuates itself and tracing the genesis and evolution of reproduction from the one-celled organism, through a myriad of intervening forms, to man. A fascinating and informative phylogenetic study."

—*The Journal of Educational Sociology*

"A book which all who venture to express opinions on sex could well consider as a sort of prerequisite to having any views on the subject." —*Journal of Heredity*

"This book deals with the development of the sexual organs and their functions from the one-celled animal to the human being. It is written, not by a sexologist or even a urologist, but by a man who is an authority on zoology and biology. It is not dry; it is not dull. It is very well translated, for the translation has not lost the wit, the Attic salt of the original. It is not a book to quote from, but a book to read." . . .

—*Bulletin of the Johns Hopkins Hospital*

"Most men and women would be better equipped to solve their sex problems if they knew more about the origin and development of the sex life.

"This book gives a detailed presentation of the gradual development of the reproductive powers and habits, from the amebæ, up through insects, fish and mammals, to man; and the unusual illustrations make the text fully clear. The reviewer knows of no other book containing similar information.

"Physicians will gain, from a study of this volume, much knowledge which will be decidedly helpful in assisting their patients in the solution of a type of difficulties which grows more common in a highly complex life such as that of the present."

—*Clinical Medicine and Surgery*

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

INTRODUCTION

MOST men and women would be far better equipped to comprehend and solve such perplexing sexual problems as arise in their own lives and in the lives of those about them, if they had greater understanding of the origin and development of the sexual impulse.

Dr. Thesing's work may aptly be termed a biologic panorama. It examines in detail the specific methods by which life, in whatever form, tends to perpetuate itself, individuals reproducing new individuals in their own images. It traces the genesis of the sex impulse through its myriad forms, from the one-celled organism to the human being, revealing how, in general, the more complex have evolved from the simpler; and in so doing it sheds important light on man's own behavior.

The title is well chosen, for it is indeed a genealogy—a fascinating and informative one—that is presented in this volume. The course of the sexual impulse is plotted with clarity and scientific thoroughness; its manifestations and mechanics are depicted in an incredible diversity of forms.

Throughout the ages man has been obsessed with a curiosity as to his origins, and manifold have been his speculations, some of them recorded in this volume, as to whence he derived. His ignorance has been a prolific source of blunders, of superstition, of intolerance, of suffering. This book will help to banish ignorance.

As animal forms, more particularly the higher primates, developed and were able to divert some of their energy from the reproductive impulse to the task of conquering an antagonistic environment, the phenomenon of mind came into being, and with it the capacity for acquiring knowledge. Gradually tradition, folklore,

superstition, prejudice began to give way to knowledge, reasoning, logic and a sympathetic understanding of the blind forces of the reproductive impulse and its frequent tyranny.

Since the early centuries when Aristotle delved into natural history, innumerable treatises have been written dealing with varied forms of sexual behavior manifest among plants, and more especially, among animals. A vast zoological literature has been built up, of observation and speculation concerning physical and mental animal functions. From this treasury of information, largely checked by his own researches, the author has selected and integrated a series running the gamut of sexual behavior mechanisms. Innumerable questions arising in the mind of every intelligent human being are thus answered in a thoroughly objective and scientific manner free from pruriency.

In spite of the fact that in the present mechanical age the human mind is intensely preoccupied with the study of the inanimate machine, there never has been a time when the spirit of intelligent and healthy inquiry concerning the processes of reproduction has been more evident or more important. Here is a work which offers a rich and reliable store of observation and information. For the man of science, it is invaluable as an authoritative treatise and reference-work; for the layman it is a book that leads to a better comprehension of his nature and that of his fellow-men.

SMITH ELY JELLIFFE, M.D.

New York,
March 15, 1934

GENEALOGY OF SEX

CHAPTER ONE

BEGINNINGS

Why do men and women kiss one another?
Why do they do so more especially in the early prime of life?
Why, above all, in the springtime?

OTHERS besides the wise old tomcat Hidigeigei have asked themselves these questions. Each one of us has, now and again, cudgelled his brains as to the meaning of the folly of love, this mingling of pleasure and pain, restlessness and joy, which periodically affects, it would seem, the whole world of living creatures.

As soon as spring comes round once more, the finches tune up, the cuckoo calls, the woods resound with the blackbird's melodious notes, squirrels chase one another from branch to branch, salmon mount the rivers, turkey-cocks and peacocks preen their feathers, sticklebacks and salamanders put on their wedding apparel, the meadows are enlivened by the cries of cicadas and crickets, the ponds are noisy with the plaintive croaking of frogs, glow-worms sparkle in the copses as they hunt for the females that crouch in the grass; bees and ants make ready for the nuptial flight; flies and gnats dance merrily in the air; swifts and swallows return from their winter quarters in the south and begin to build their nests; " in the spring a livelier iris changes on the burnished

dove"; the old tomcat Hidigeigei (or his descendants) troubles our sleep by caterwauling and spitting on the house-tops; the "spring running" has begun and the whole animated world has been seized with intoxication. Nor is man, the crown of creation, spared this universal frenzy; "in the spring a young man's fancy lightly turns to thoughts of love"; couples, arms interlaced, wander down the lanes and across the meadows; a magnetic force, an irresistible elective affinity, draws the sexes together; the great renovative process of organic nature has begun.

In truth, hunger and love rule the world, both of them fulfilling an important biological function, both indispensable to the continuance of life. Were it not for the promptings of hunger, the living creatures that populate land, water, and air would speedily die out. Were it not for the promptings of love, every species would soon become extinct. In the individual body, hunger arouses a sense of discomfort, quickens the impulse to seek the nutriment which alone can dispel this uneasiness. The lower animals remain unaware of the causal connection between hunger and the ingestion of food, even as to primitive man the relationship between sexual intercourse and the procreation of children was still unknown.

In its spherical resting-stage, an amœba may remain for a considerable period motionless at the bottom of the pool in which it lives; but, inasmuch as it lives, a process of combustion goes on within it, metabolism, tissue-change. Because of this tissue-change, minimal though it be, a sense of discomfort, of hunger, ultimately arises. The discomfort awakens the amœba from its slumbers; cautiously it thrusts forth a pseudopod, followed by

another, and it crawls slowly along. If it encounters a grain of sand, this is surrounded by the cell-substance and ingested, to be rejected after awhile as useless. In like manner, without (one must suppose) conscious aim, algæ and other tiny nutritious fragments are incorporated by the amœba and subsequently ejected, but in their case only after the little creature has extracted from them the materials requisite for the maintenance of its own existence, those that will supply what is used up during its own vital processes. When the amœba has, in this primitive fashion, assimilated a sufficiency of organic nutriment, the unrest of hunger is allayed, and the protozoon relapses into the apathetic resting-stage of digestion. (See Fig. 1.)

The sexual impulse, like hunger, gives rise to disturbances in the body, arouses a sense of discomfort, a yearning, a sense of internal unrest. Dependent primarily upon chemical tensions, this feeling of unrest impels males and females of the same species to the sexual act, which discharges the aforesaid tensions and relieves their discomfort; so that, though they know not what they do, by their action they fulfil the main purpose of organic nature—reproduction, multiplication, the preservation of the species.

It is not a wish for offspring that produces the impulse which brings the sexes together. Reproduction is the outcome of blind instinct, is but one of the manifold ways in which nature sees to it that the life of the species shall be continued. A knowledge that coitus and reproduction are intimately connected, the conscious performance of the act of copulation in order " to raise up seed ", appears in the world at a comparatively late stage in the

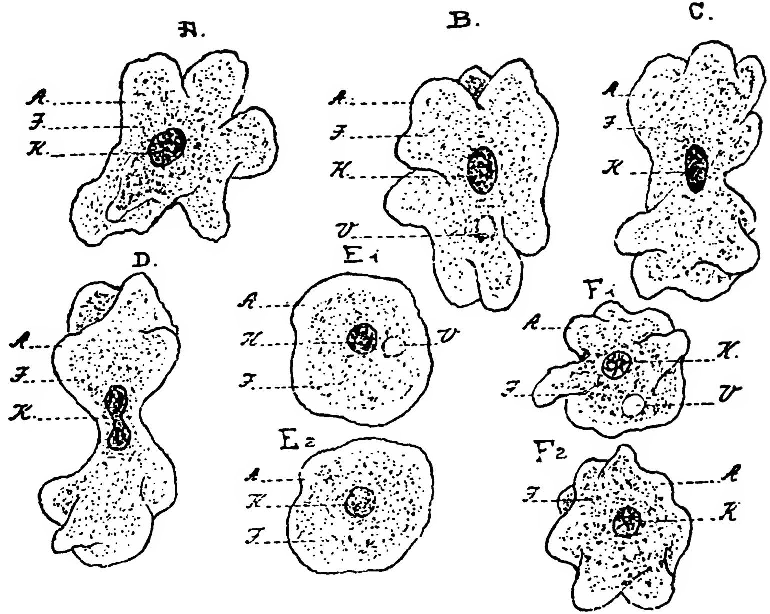


FIG. 1.—ASEXUAL REPRODUCTION IN THE AMŒBA.

A, clear outer protoplasm. J, granular inner protoplasm. The outer and the inner protoplasm form in conjunction the cell-body. K, nucleus. V, contractile vacuole, the simplest form of kidney. A, a normal amœba, with numerous pseudopods, in the act of crawling. B, an amœba preparing to divide, its body having become elongated. C, the nucleus is likewise elongated, and a furrow has appeared round the middle of the body. D, the constriction has involved the nucleus as well. E1 and E2 : F1 and F2 : the two daughter-cells that have resulted from division of the mother-cell.

history of the human race when man has achieved a considerable level of civilisation. Nay more, this awareness which has only come to man as the sequel of a lengthy period of evolution, this awareness which (in a measure) subordinates a coercive natural impulse to intelligent control, is a late biological development which may, in due course, lead to the extinction of our race unless there concurrently takes place a no less vigorous moral development, a no less active growth of the sense of responsibility.

Love with all its bodily and mental manifestations; the myriad means and apparatus whereby the reproduction of the animals and plants which now inhabit the earth is secured, whereby the sexes are mutually attracted, procreation is effected, and the upbringing of the young is safeguarded; the organs by which the male clasps the female, the stimuli by which sexual pleasure is intensified, the lures of the female, the weapons of the male, the ebb and flow of the hormonal tides, the rutting period—these things did not exist when life first appeared upon earth, but have been gradually evolved in the course of millions upon millions of years, as the result of a slow process of differentiation. Like hunger and pain and fatigue, love, too, is a phenomenon of adaptation, slowly created by the struggle for existence in the widest possible sense of that term (a sense which has been modified, perhaps, since the days of Darwin), and perfected by inheritance. If animals did not suffer from hunger, they would have no impulse to hunt for food; and (since the living organism, however primitive, is always undergoing a process of tissue-change, since it is an internal combustion motor which cannot maintain its

vital functions without consuming material and since this consumed material has to be replaced) the body would soon perish were it not for the ingestion of nutriment. Again, if man felt no pain from a scratch, a knock, or a burn, if his nervous system failed to warn him when he injured himself and thus to induce caution, he would speedily be destroyed by the manifold noxious influences to which he is perpetually exposed. Pain is a signal that there is something amiss.

Since nature is perpetual development, nature cannot be perfect. Perfection excludes evolution, would be definitive, nirvana, death. Much that we, in our unreason, complain of as nature's imperfections, much on whose account we find fault with our Creator, has, in this imperfect but evolving world, a profound biological significance as a means for the realisation of an unknown plan.

We grumble if, when climbing a mountain, we find that fatigue impairs our pleasure, compels us to rest for a time in order to recruit our energies. Would it not be better, we say to ourselves, if we could be spared these distressing sensations? Yet this sense of fatigue is a valuable safeguard which protects our organism from excessive strain. The sensation of fatigue announces to the body that it is beginning to exceed its powers and that it will do itself harm if it continues its activities. Every muscular contraction produces in the muscle concerned poisonous excretory products, the toxins of fatigue, which are for a time stored up in the tissues and which, when their quantity becomes considerable, arouse that sense of weariness which calls a halt to the body. Not until, during a period of repose, the blood-

stream has carried away these fatigue poisons, and not until they have been eliminated from the body, does the sense of fatigue pass away so that activity can be resumed without peril. This applies equally to physical and to mental exertion. We do not cease working because we have become absolutely unable to continue at work, but because nature sees to it that when intoxication with fatigue products reaches a certain though not yet dangerous measure the will to labour shall relax. An excess of function is only possible at the cost of more or less serious bodily hurt.

The sexual impulse, likewise, is one of nature's essential resources, and cannot be regarded as in itself sinful or objectionable. In itself it is neither good nor bad, " but thinking makes it so ". If the sanctimonious could attain their ideal of eradicating the sexual impulse, the species would die out!

There can be no doubt that hunger is the most primitive, the most universal of impulses, having come into existence with the first appearance of the most primitive organisms in the world, for life is synonymous with tissue-change, with the consumption and replacement of the substances out of which living tissue is made, the need for their replacement arousing hunger in order that food shall be ingested. As to whether love, that is to say the sexual impulse in its most elementary form, in the form of an elective affinity drawing together two individuals of the same species, also arose at the very outset of the appearance of life on earth—this remains uncertain. We know that the simplest animal organisms reproduce themselves by fission, one individual dividing into two. (See Figs. 1 and 2.) They ingest more nutriment than

they need for their maintenance at their existing size, they turn this food into new bodily substance, and thus continue to grow until the maximum dimensions proper to the species have been attained. Thereupon they spontaneously divide into two lesser organisms, each of which begins to feed and grow on its own account, and divides in its turn when the time comes. Feeding, growth, division ; feeding, growth, division : such is the rhythm of multiplication from generation to generation, continued, presumably (as far as these organisms are concerned), to all eternity, or until the cooling of the earth makes it unsuitable for the further continuance of organic life. The original forms of reproduction may be described as a growth in size until the specific maximum is reached, followed by division. Something similar is observable in the inorganic world in the case of the fluid crystals. These myelinoid fluid crystals grow like living organisms by intussusception. Like organisms, too, they crawl hither and thither, or assume looped forms like those of many bacteria. They even divide like these into two or more portions, which then behave like completely new individuals, grow, and in turn subdivide.

There are good reasons for supposing that after the origination of the first living creatures this method of reproduction by simple division must have gone on for many millions of years. But such a mode of reproduction could not lead to any sort of progressive development. The two parts into which one of these extremely primitive organisms divided, the two daughter-cells resulting from the division of the mother-cell, must have resembled the parental organism in every detail. They

must have been devoid, or almost completely devoid, of variability, of the capacity for adapting themselves to new conditions, of the power of further evolution. There is no need for introducing teleological considerations, no need for ascribing to nature or to the Creator human aims and purposes, no need for picturing the realisation of a plan fixed from the outset. Simple observation convinces us that nature, and organic nature above all, undergoes continual evolution; that living creatures are always advancing, I will not say from lower to higher forms, but from simpler to more complex forms. What we call "progress" is an advance from the simple to the complex. Just as a symphony stands on a more lofty plane of evolution than a folk-song, so does the monkey stand on a higher plane than the amœba, and the civilised human being upon a higher plane than Neanderthal men. He is a more complicated, a more highly differentiated machine.

A genuinely progressive development, something which is more than the mere reproduction and diffusion of a species, only becomes possible when two distinct individuals with varying individual qualities unite for the reproductive act, and when, out of their united bodies or reproductive cells, there arise offspring in which the diversified characteristics of the parents are contained and can disclose themselves. Only by such an amalgamation, by the division of the species into two sexes the members of which reunite in the sexual act and interchange their respective hereditary qualities, is there produced a greater capacity for variation which, in the long course of time and through successive generations, leads by adaptation, inheritance and selection to new

forms of life. Amphimixis, the mingling of the nuclei that contain the respective hereditary aptitudes of two different individuals, is the ultimate significance underlying all sexual phenomena and all sexual behaviour.

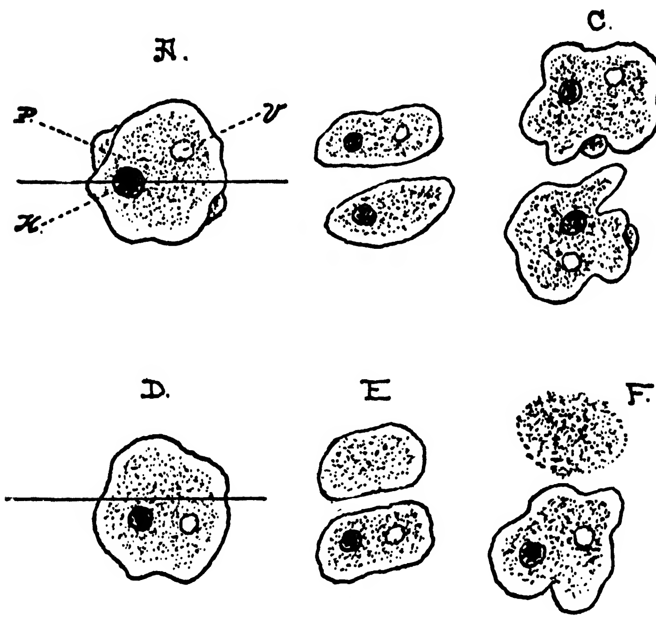


FIG. 2.—ARTIFICIAL DUPLICATION OF AN AMŒBA BY SECTION.

P, protoplasm. K, nucleus. V, vacuole. The straight line across A indicates the section that was made through the nucleus as well as the cell-body. B shows the two segments, each containing a nucleus, immediately after the section. C shows the two normal amœbæ that have resulted. The lower amœba has formed a new vacuole. The straight line in D indicates a section which does not pass through the nucleus, and E shows the resulting segments, one of which has no nucleus. F shows how the upper segment is perishing, only the lower one (which contains the nucleus) having developed into a normal amœba.

Love, the sexual impulse, and the amphimixis that results from the working of this impulse, presuppose a partner towards which the sexual impulse is directed. Not until a species has been subdivided into individuals of two different sorts, of two different sexes, not until there has been a differentiation into masculine and feminine, can the sexual impulse develop, and perfect itself.

We cannot be absolutely certain whether there still exist organisms entirely devoid of sexual processes. The fact that evidence is negative cannot be regarded as positive proof. Artificial culture of some of the lowly organisms has, indeed, shown that there are certain living beings which appear to be capable of reproducing themselves asexually for countless generations. In many such instances, it is true, we observe after a time the appearance of degenerative phenomena, taking the form of a slackening of the process of fission. In many other cases, on the other hand, these manifestations of fatigue are lacking. Eudorina elegans, one of the volvocineæ or spherical algæ, has been cultivated for ten years during which asexual reproduction persisted through three thousand generations of healthy offspring. In the case of the "slipper animalcule", paramæcium, more than eight thousand successive generations have been reared in the course of eight years. But whereas some observers have declared that the latest generations were as lively and cheerful as the first ones, others maintain that after a very large number of such successive acts of asexual reproduction there have been noticeable phenomena of depression, the act of division taking considerably longer, the organisms resulting from the fission remaining smaller

than the average, and their mortality increasing. Still, even in higher organisms than these, even in some of the metazoa (multicellular animals), as, for instance, certain planarians, more than a hundred successive divisions have been observed without any interruption of this asexual reproduction by conjugation in whatever form. In various worms, such as pristina, a fresh-water chætopod, no sexually differentiated individuals have ever been discovered. As far as our experience goes, these creatures continue to reproduce themselves asexually by fission. Since, however, both in eudorina and in paramæcium living under natural conditions, asexual reproduction is from time to time replaced by sexual reproduction, and inasmuch as some of the close kin of pristina reproduce themselves sexually as well as asexually, it is highly improbable that in pristina we have to do with a primary state of affairs. We must, rather, assume that, owing to the operation of causes still beyond our ken, external influences have deprived pristina of a capacity for sexual reproduction which this creature originally possessed. There is, indeed, considerable ground for believing that we are concerned here with degenerative phenomena, that these organisms have passed the climax of their evolution and are on the way to extinction. We have direct evidence that external conditions, such as the removal to an unfamiliar climate, can affect the mode of reproduction. A striking instance is that of certain Indian grasshoppers which, when transferred to Europe, produce males in very small numbers or not at all, so that the life of the species is maintained almost exclusively by parthenogenesis, that is to say, by the hatching-out of eggs which have not been fertilised by male sperm.

Probably the first forms of organic life that appeared on earth were unisexual, or rather asexual, being equipped with only this extremely simple way of maintaining the life of the species, one which scarcely affords the possibility of further evolution. For, as I have already explained, the offspring thus produced by simple fission differ from their parents only in respect of size, and can contain no other heredity factors than those that were possessed by the parent organisms—unless we assume that through the sudden appearance of extensive variations or mutations new qualities which were not part of the primary and inherited equipment spontaneously arise. Apart from this possibility, in such asexual organisms the possibilities for variation and therefore adaptation to changing conditions of life must have been very small. The progressive evolution of organic life only becomes possible through the separation of a species into males and females capable of mingling their hereditary characteristics in a primitive sexual act. As to how the differentiation actually occurred, as to the nature of the energy which can for the first time have impelled two individuals of like kind to fuse their protoplasms in an act of conjugation, are left to supposition. Maybe in a very early stage of organic life such conjugation took place experimentally and as it were by chance, when, from time to time, two such minute masses of living protoplasm came into contact in their wanderings. Since, however, it is plain that this transient fusion of two different organisms (a fusion which cannot as yet be regarded as a sexual process or as reproduction) must have proved advantageous, as time went on it became a regular practice, the outcome of an impulse established in the life-cycle

of the organisms concerned. We know that the soft crystals of para-azoxy-benzoic-acid-ethyl-ester, when they come into contact, diffuse into one another to form new and larger units, which break in twain after a time. Outwardly the conjugation of some of the simplest living organisms closely resembles this behaviour of the fluid crystals, but the union of the latter is certainly not in any sense a sexual process. Their mutual attraction is an expression of that attractive force which dominates the universe. Using the term "love" in the widest sense, we may speak of it as an attraction between two like bodies, as a craving for union and amalgamation. This attractive force regulates the movements of the heavenly bodies. The stars themselves experience a vital cycle. They are born in a state of fiery vapour, undergo differentiation as they cool, exhibit a separation into land and water and atmosphere, produce a wealth of organic life upon their surfaces, and then, as they grow old, sink into a condition of icy repose—unless a union with some other heavenly body which crosses their path should give their life a fresh impetus. Unceasingly they strive towards one another, but are held apart by other forces, until the overpowering attractive energy of one partner upsets the balance of the system. Then this attractive force brings the loving couple together, they fuse in an ardent embrace, a new starry world results from their union, and the whole cycle of development is started afresh. No doubt this is a mere image, a superficial analogy—but perhaps the parable embodies a profounder significance.

Just as the conjugation of fluid crystals when they come into contact cannot be regarded as a sexual act, so

we are forced to assume that there was no sexual significance in these occasional encounters and fusions of the most primitive forms of living organisms. But such chance encounters, occurring perhaps as a modification of the taking-in of nutriment, proved advantageous, and thus by degrees, through a change of function, became significant and valuable for reproduction and evolution. Observations made upon various unicellular protozoa suggest to us how out of these chance encounters an impulsive search for one another may have developed. Beyond question it must often have happened that two little creatures of the same kind on the prowl in search of food must have got into touch with one another, and, since their frail protoplasmic bodies (not as yet possessing any firm envelope) must have run together as easily as two drops of water or two fluid crystals, there will have occurred a transient union of the plasma masses, followed by a speedy re-separation into two distinct organisms. At first this had nothing to do with reproduction, and even as regards the ingestion of food it is probable that the casual unions only became serviceable by degrees. The larger, conjoined plasma-body was capable of ingesting larger fragments of food than the separate individuals had been, so that these little animals, whenever hunger troubled them, began to be moved by an impulse towards other creatures of the same species with which they could unite.

This is not a vague hypothesis. The assumption is supported by manifold observations upon primitive organisms which have survived into our own day. Often when we are watching the sun-animalcules or heliozoa on their hunt for prey, we shall see one of them come

into contact with a larger infusorium and try to grasp the creature in its radiating processes or pseudopodia. One heliozoon alone will not succeed in this. The infusorium will shake itself free from the tentacles of the hunter and swim away. Sometimes, however, a second, a third, a fourth heliozoon will come to the assistance of the original aggressor, and they will all clasp the infusorium with their pseudopodia. They surround their victim as hunters surround their quarry. Then a strange thing happens. Wherever the pseudopodia of the heliozoa come into contact with one another, they fuse. Gradually the pseudopodia contract and thicken, bringing the little creatures closer and closer together; the ring grows smaller; at length the bodies of the hunters touch that of their prey and begin to flow over its surface. The booty is now helpless, bedded in a single mass of protoplasm larger than itself. The heliozoa remain united until their prey has been digested. Then they separate. Each of them, seemingly unaltered, takes its own path, until hunger and chance bring them together elsewhere, and a fresh union of their plasma bodies occurs. Manifestly, here, we have no sexual process, but merely a union of huntsmen. The nuclei of the heliozoa (which, as we shall presently learn, play the leading part in the sexual act) are unaffected by the union of the cell-bodies, remaining distinct one from another in the conjoined plasma.

Still, even though the individuals fall apart as soon as the purpose of their joint search for food has been fulfilled, some interchange of substance must have occurred. The heliozoa after their temporary union must be differently constituted in some respects from

the heliozoa that entered into the union; in part the body of each must contain substances derived from the bodies of their allies.

To-day the lowest forms of individual living creatures known to us are unicellular organisms which, however primitive, show plainly—through their differentiation into cell-body and nucleus—the traces of a long genealogy. If we assume the spontaneous generation of life to have occurred upon our planet, we cannot but suppose that the organic substance first developed out of inorganic materials must have been far simpler, far less differentiated than this. In the nucleated cell of the protozoon, adaptation and evolution have already led to far-reaching differentiations. If we reject Arrhenius' hypothesis that the most primitive organisms were brought to earth on a meteor, and that from them organic evolution began, if we suppose that the first living inhabitants were spontaneously generated on our earth as it cooled, we can confidently assert that at the outset there was in them no differentiation into cell-body and nucleus. Since we have no direct experience to inform us regarding these remote days, we are left guessing.

However these things may be, returning to life upon the earth as we now know it, one who would understand the processes with which we are concerned in this book must be acquainted—at least in broad outline—with the structure of extant cells and with the processes that take place within them during fertilisation and the transmission of heredity factors. (See Fig. 3.)

The cells, the ultimate elements of living substance, whether isolated as in the protozoa, or as citizens of a

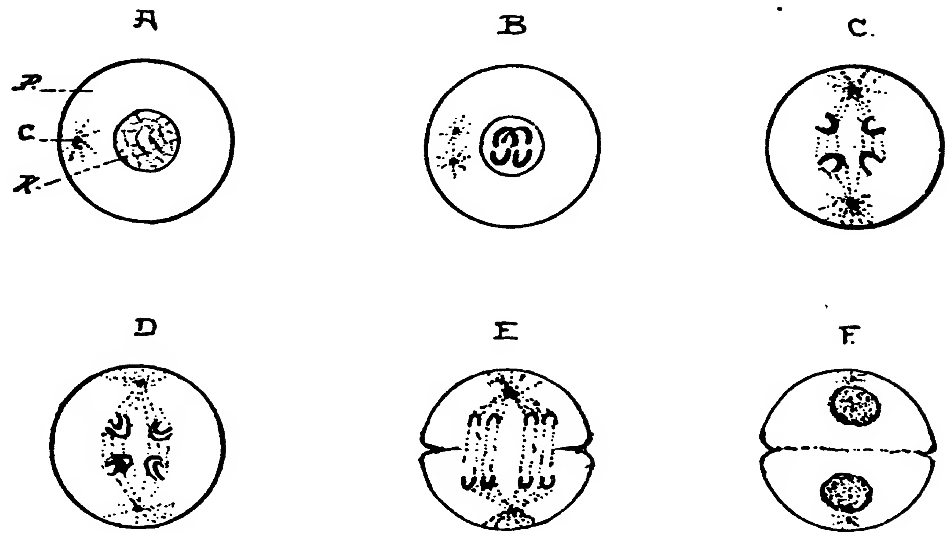


FIG. 3.—DIAGRAMMATIC REPRESENTATION OF CELL-DIVISION.

A, resting cell about to divide. P, protoplasm. K, nucleus. C, centrosome. The radiating filaments that form round the centrosome are the first signs that division is imminent. In B the centrosome has divided, and the products of this division migrate to the poles of the cell, so that the nucleus (in which the chromatin has ranged itself in four chromosomes lies between them. C, the chromosomes have formed the equatorial plate; the nuclear membrane has disappeared. From the centrosome, fine filaments extend to the chromosomes, which seem to cling to them, with the result that the typical spindle-shaped figure is produced. D, the chromosomes have split longitudinally and are moving towards the centrosomes. E, the cell-body is becoming constricted across the middle. F, cell-division is finished. In the two daughter-cells the chromosomes have coalesced into ordinary nuclei.

cell-state as in the metazoa (to which more complex type of organisms we human beings belong), always consist, apart from secondary differentiations, of protoplasm and nucleus. The protoplasm of the cell-body is concerned in vegetative processes and in movement; the nucleus, on the other hand, is the regulator of the vital processes, and is, in especial, concerned with the preservation of the species and with heredity. In the nuclear chromatin (the substance in the nucleus which stains more deeply than the rest), segregating itself during cell-division into chromosomes (shown in Fig. 3), all the heredity factors exist in a latent condition. Since every organism has ultimately arisen out of the union of a maternal and a paternal cell, every heredity factor exists in a duplex form, one deriving from the mother and the other from the father. These heredity rudiments or genes are arranged in the chromosomes like pearls upon a string. In the animals of any particular species, the number of chromosomes is invariably the same in all the cells of the body, and since the father and the mother make an equal contribution to the chromosomes of the offspring, the number of these in the cells is always an even one. For instance, the body-cells of human beings contain forty-eight chromosomes. The round worm, Ascaris megalocephalia, has four, the lily has twenty-four, a little crab called artemia has one hundred and twenty-four. Thus the number of the chromosomes is certainly not dependent upon the position in the " scale of creation ". Since the individual chromosomes differ from one another in form and size, it is possible to observe that in the body-cells they are always present in pairs, and we have evidence to show

that one member of each pair is of maternal and the other of paternal origin.

When a cell divides, during a complicated process of nuclear division the chromosomes split longitudinally, one-half of each chromosome going to the nucleus of each daughter-cell, so that the daughter-cells have both quantitatively and qualitatively the same hereditary equipment. But there is a notable exception (an isolated one) to this rule in the formation of the reproductive or sexual cells. In the formation alike of the ovum and of the spermatozoon, during the course of what is termed the first maturation division, no longitudinal splitting of the chromosomes takes place. On the contrary, the chromosomes arrange themselves in pairs in the so-called equatorial plate, and in the cell-division that follows one member of each pair makes its way into the nucleus of the daughter-cell A and the other member of the pair into that of the daughter-cell B, each of these daughter-cells developing into a mature reproductive cell. Thus both ova and spermatozoa contain only half the number of chromosomes which are present in the body-cells of the animal or plant concerned. In other words, during the formation of the reproductive cells the paternal and maternal chromosomes separate, with the result that the mature spermatozoon and the mature ovum contain, each, only an assortment of the heredity factors for a new individual. (See Fig 4.) However, this assortment can contain, in a varied mingling, groups of heredity factors, some of which derive from the father and others from the mother. Let us suppose, for instance, that in its body-cells an animal has eight chromosomes, that is to say four pairs, and that we

denote those deriving from the father as A, B, C, D, and those deriving from the mother as *a*, *b*, *c*, *d*. Then, during the formation of the reproductive cells, when the chromosomes are allotted to the mature sexual cells, whether these be ova or spermatozoa, there is an equal likelihood of any one of the four following combinations arising: 1. ABCD; 2. *a*BCD; 3. *ab*CD; 4. *abc*D; 5. *abcd*; 6. A*bcd*; 7. AB*cd*; 8. ABC*d*.

This signifies that reproductive cells may in certain cases be equipped exclusively with heredity factors deriving from the father (ABCD) or exclusively with heredity factors deriving from the mother (*abcd*); or the heredity factors of the parents may, in the mature reproductive cells, be combined in any other way as determined by the calculus of probability. Since, however, the paired chromosomes can exchange one for another their smaller maternal or paternal heredity units or genes, the possibility of combinations is far greater than this, and the offspring arising from the union of these reproductive cells may bear in their bodies the most diversified mingling of paternal and maternal heredity factors. Yet it is not only the heredity factors derived from the father and the mother which are contained in the chromosomes and transmitted by them, but also the heredity factors of previous generations, so that in an individual a characteristic may manifest itself which was manifest in a remote ancestor and has lain hidden for generations in the germ-plasm of the paternal or maternal line. In this choice among the most diversified possibilities, in this amplification of variability, and in the resulting increased power of adaptation, lies the profound significance of sexual reproduction. The enormous

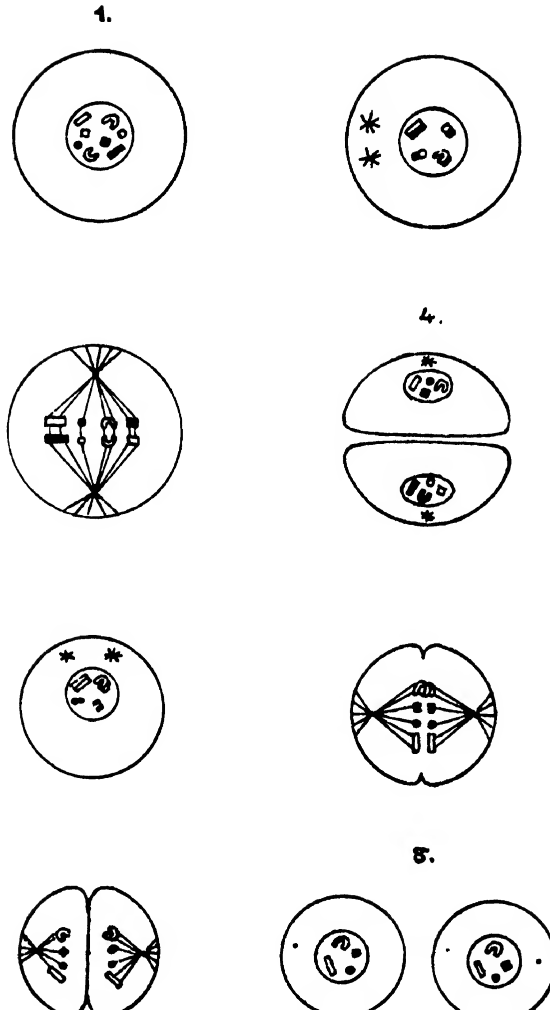


FIG. 4.—REDUCTION DIVISION IN A SPERMATOGONIUM.
The blacked chromosomes are of paternal origin; those shown in outline only, of maternal.

number of apparatus and institutions which nature has devised to bring the sexes together in the reproductive act aim, one and all, at ensuring that a spermatozoon shall enter an ovum and shall thus provide a new generation with a new combination of heredity factors.

This is a matter which cannot be more fully discussed here. Readers who are interested in it need only consult a modern manual of heredity.

In the most primitive organisms, before any differentiation into protoplasm and nucleus had occurred, we will suppose that the heredity factors were still diffused throughout the cell-body, and that when, in their hunt for food, such organisms encountered one another by chance and fused, there must have occurred, as part of the general exchange of substances, an exchange of hereditary qualities, with the result that, after they had separated, such animals must have had more variability than before and a higher capacity for adaptation. In this way they would have acquired an advantage in the struggle for existence as compared with those members of their species which had not undergone such a fusion. It is thus we can imagine sexual reproduction to have first come into being, and that from these primitive beginnings in the course of millions upon millions of years there has arisen the amazing multiformity of extant reproductive mechanisms.

CHAPTER TWO

FROM THE SEXUAL ANIMAL TO THE REPRODUCTIVE CELL

may love, thus may the sexual life, have come into being. Such a process is conceivable. Certainty in the matter could only be attained if scientific investigators were able in their laboratories to reproduce the conditions under which the first living forms developed out of inorganic matter, if they could synthetically construct the albumins which form the material substratum of tissue-change and of the other vital processes, and if they could kindle in these the flame of life. In decades of laborious research, Emil Fischer and his pupils were able to gain a broad idea of the chemical structure of these albumins and to show that we have to do with manifold groupings of amino-acids ; but the variety of combinations of these amino-acids is so great that if there were but twenty of them this would furnish the possibility of the almost inconceivable number of round about 2,300 trillions of isomers. To select from among such abundant possibilities is a task from which the boldest investigator might shrink. It is likely, therefore, that a long time will elapse before we have any guide but hypothesis as concerns the origin of life and the beginning of sexual reproduction. When we turn, however, to the study of the vital and amatory processes in the simplest living beings that now exist on earth, we

tread the firm ground of observation and ascertainable facts.

Anyone can make such observations for himself. All he needs is a microscope, glass slides and cover-slips, some glass vessels, a talent for observation, and patience—a great deal of patience. If you take a glass jam-pot, throw into it a handful of dried leaves, and half fill the vessel with water, you will find that within a few days the water is alive with all kinds of protozoa, unicellular organisms, amœbæ, infusoria, etc. The almost universally diffused and graceful slipper animalcule or paramæcium is rarely missing in such a culture. Under the microscope we can watch it swimming briskly hither and thither in search of food. From time to time we see a furrow appear in the middle of a paramæcium's body, and this furrow grows deeper and deeper until at length the little creature has split into two daughter-cells which, through growth and the appearance of the lacking parts, are quickly converted into complete slipper animalcules. As already stated in the first chapter, paramæcia have been cultivated for many years in succession until more than eight thousand asexual generations have been produced. How vast a number of offspring one such protozoon can produce in a single year can be readily estimated since we know that at a temperature round about 68° F., that is to say the ordinary temperature of a living-room, it usually divides twice in twenty-four hours. This signifies that after twenty days a parent organism will have reproduced itself so abundantly that there will be 1,042,176 specimens. In a year the number of the offspring, were there no check on production, would attain cosmic proportions.

Should the observer relinquish his task prematurely,

he would be apt to assume that such reproduction by simple fission might go on in like manner to all eternity. It is improbable, however, that this can happen. After reproduction in the culture-glass has proceeded as above described for a time, we note a remarkable change in the nature of the infusoria. Some of the protozoa which we have removed from the jam-pot with a pipette and subjected to examination under the microscope will have been seen to swim about in couples, close together, as if drawn towards one another by unseen forces. At length the members of such a pair come so close that their anterior ends are in actual contact. Their little mouths are pressed together, and in the region of the oral orifices the two paramæcia unite by means of a broad bridge of protoplasm. The culture seems to have become affected by an epidemic of pairing, by a frenzy for conjugation. Here, once more, we note the periodicity which appears to dominate the whole of life, and which is recognisable in the females of the human species in the monthly ripening and discharge of an ovum with the subsequent menstruation. We do not know precisely what it is which, at particular times, incites the paramæcia to pair. Presumably certain chemical substances are excreted by them, and these make the animals attract one another. Experiments on ferns show that chemotaxic influences are probably at work in such cases. The female reproductive cells of ferns produce malic acid to attract the spermatozoids, which, in these plants, are free-swimming male gametes. If we fill a capillary tube with water containing no more than 0·000,000,000,028 of a gram of malic acid and dip the open end of this tube into a drop of water containing fern spermatozoids, these spermato-

zoids will speedily find their way into the tube. In the case of the human ovum likewise, chemical lures excreted by the uterus and by the ovaries serve to attract the spermatozoa. The chemical nature of these attractive substances is still unknown, but it is easy to demonstrate that they exist. If, under the microscope, we insert a minute fragment of muscular or connective tissue into a specimen of human semen we are examining, the spermatozoa which swarm on the slide show no interest in it; but when, on the other hand, we introduce a tiny scrap of uterine mucous membrane or of ovarian substance, all the spermatozoa in the field of observation swim rapidly towards it.

The act of conjugation between two paramæcia lasts from twelve to fourteen hours; then the individuals separate, and each of them devotes itself to a new series of fissions, until, after a longer or shorter time, a period of conjugation recurs.

Paramæcium stands at a comparatively high level among the protozoa. Its cell-body has a fixed shape, resembling that of a slipper. The surface of the body is richly beset with fine vibrating filaments called cilia, which serve as locomotory organs and also for producing water currents which bring nutritive fragments towards the little animal's mouth. Nutrition is no longer, as in the amœba, effected at any and every part of the body, which (in the amœba), as previously described, flows round its prey. The slipper animalcule has a permanent mouth and gullet through which the fragments of food pass into the interior of its body. Above all, however, the nuclear apparatus of paramæcium is highly developed. In the resting-stage of the organism we can discern in the

cell-body a main nucleus or macro-nucleus and a small accessory nucleus or micro-nucleus. At ordinary times, the micro-nucleus remains apparently inactive amid the protoplasm of the cell-body, the vegetative activities of cell life, movement, the ingestion of food, and digestion being controlled by the main nucleus. But as soon as the animal is about to conjugate, the micro-nucleus becomes active and assumes the leading rôle. This micro-nucleus is pre-eminently the sexual nucleus. In this conjugative phase, the main nucleus has fulfilled its task, and perishes during the act of conjugation, breaking up into a number of irregularly shaped fragments which are gradually absorbed into the protoplasm. (See Fig. 5.)

Shortly after two paramæcia have begun the act of conjugation, their respective cell-substances being brought into direct communication by the formation of a bridge of protoplasm, in both the conjugating animals the micro-nucleus becomes enlarged, elongated, and subdivides into two micro-nuclei, this process being accompanied by an elaborate distribution to each of them of the chromatic nuclear substance which contains the hereditary equipment. Whereas in the ordinary process of fission a division of the nucleus is succeeded by a division of the cell-body, the two newly formed cells then passing into a resting-stage, during which the subdivided nucleus of each cell grows to its full size—here cell-division and resting-stage are absent. The two micro-nuclei further subdivide so that now in each conjugating cell-body there are four micro-nuclei. Three of these micro-nuclei perish after a little while, being reabsorbed by the protoplasm; the fourth micro-nucleus, absorbing fluid, grows to the original size of the micro-nucleus, and then proceeds

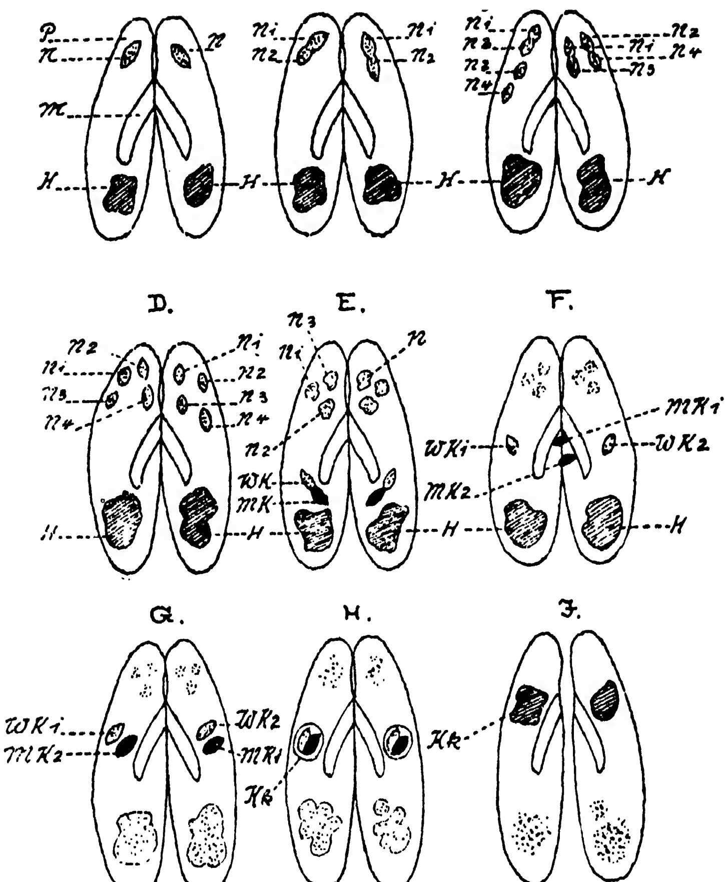


Fig. 5.—Sexual Reproduction in Paramæcium.

P, cell-body. H, macro-nucleus. N, micro-nucleus. M, mouth. Ni–N4, daughter-nuclei produced by division and redivision of the micro-nucleus. WK, female or stationary nucleus. MK, male or migratory nucleus. K*k*, conjugation nucleus, formed by the new macro-nucleus and the new micro-nucleus.

to divide once more. There ensues the true process of fertilisation, the entrance of alien nuclear matter, of an alien hereditary equipment, into the body of the partner. In paramæcium, however, no separation of the sexes has as yet occurred; none of the paramæcia are distinctively male or female. The creatures are not asexual, but unisexual, or, more strictly speaking, hermaphrodite. Male and female elements exist side by side in the micro-nucleus or sexual nucleus, and do not separate until the micro-nuclear division of conjugation takes place. At this time they separate into the female nucleus which remains *in situ*, on the one hand, and the migratory micro-nucleus, the male micro-nucleus which effects the act of fertilisation. In the metazoa, the higher multicellular animals, we shall make acquaintance with the most diversified forms of hermaphrodism. Some of these hermaphrodite metazoa have entirely distinct male and female reproductive glands, testicles and ovaries, with separate excretory ducts; others have a hermaphrodite reproductive gland, an ovo-testis in which ova and spermatozoa are produced simultaneously or successively. As a rule among the higher organisms in which hermaphrodism prevails, the ripening of one type of sexuality precedes the ripening of the other type, so that when coitus takes place one of the partners is acting as a male and the other as a female. Still, there are instances among the metazoa in which mutual coitus takes place, each individual of the pair acting simultaneously as male which fertilises and as female which receives the sperm. This happens in earthworms, snails, etc.

In paramæcium we see this mutual impregnation in its simplest possible form. The male micro-nuclei of the

respective conjugating cells migrate across the broad protoplasmic bridge by which these cells are temporarily connected, approach the quiescent micro-nuclei of the partner cells, and, in the act of fertilisation, fuse with these to form a conjugation nucleus. Thus is fulfilled the object of every act of fertilisation, namely, the exchange of the hereditary equipment of two individuals, the union of maternal and paternal rudiments to form the micro-nucleus of the fertilised reproductive cell—which, in these unicellular organisms, is also the complete individual.

When this act has been completed, the protoplasmic bridge breaks in sunder, and the act of conjugation is finished. But in the interior of the protozoon the sexual process is carried a stage further, for the conjugation nucleus divides into two portions, one of which grows to become the main nucleus, the macro-nucleus which controls the vegetative life of the animal, whilst the other remains smaller, a typical accessory nucleus or micro-nucleus, whose chromatin is now equipped with the hereditary units derived from two individuals. In the reproductive process which is, for many subsequent generations, continued by simple fission, the micro-nucleus transmits to the daughter-cell its enriched hereditary equipment, whereby the capacity for variation and adaptation is increased.

We see that there is a remarkable conformity between the conjugation of these unicellular organisms and the maturation division of the ova and spermatozoa and the process of fertilisation in the higher, the multicellular organisms, whether plants or animals. From the division of the mother-cells of the spermatozoa and the ova to

form these latter, there arise in each case, thanks to two successive maturation divisions succeeding one another without a resting-stage, four spermatozoa or ova, as the case may be, whose nuclei contain half the number of chromosomes characteristic of the body-cells of the animal in question. For, during the maturation division, the paired paternal and maternal hereditary rudiments separate, and are allotted, by a chance distribution it would seem, to the two daughter-cells. (Refer back to Fig. 4.) Only when fertilisation takes place and when the head of the spermatozoon (which is the nucleus of the male reproductive cell) makes its way into the ovum and fuses with the latter's nucleus, is the number of chromosomes restored to the normal. The fertilised ovum contains for every heritable quality two latent heredity factors, one deriving from the maternal line and the other from the paternal. Inasmuch as, during the subsequent division of the ovum and the further subdivision of the daughter-cells repeated again and again to form in due time the adult organism, this hereditary equipment is equitably assigned to the successive generations of daughter-cells, every cell in the adult body contains precisely the same hereditary equipment as the fertilised ovum, and, from a theoretical outlook, might be regarded as capable of generating a perfect young organism. In the case of the metazoa, however, the specialisation and differentiation requisite for the peculiar tasks the body-cells have to fulfil in the organism is accompanied by a loss of the faculty for reproducing an entire organism. Still, there are many of the higher multicellular animals and plants—especially the latter—whose cells retain, even in the adult organism, this embryonic capacity. From

a tiny fragment of begonia leaf, a fragment consisting only of one or two cells, a complete begonia plant can be grown, asexually; and small pieces cut out of the bodies of many of the lower worms are competent to reproduce the missing parts and to develop into fully equipped adult members of the species. (See Fig. 6.)

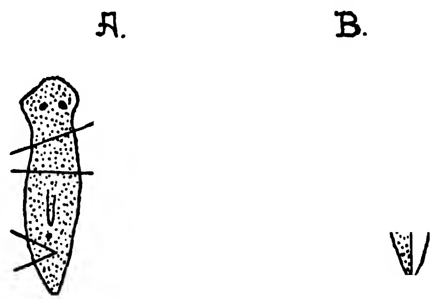


FIG. 6.—ARTIFICIAL DIVISION OF A PLANARIAN.

The straight lines denote the planes of section. The parts left white in the bodies of the animals represent the newly formed portions.

Above all in the maturation of the ovum, the conformity with the internal processes that occur during the conjugation of the infusoria is almost perfect. Of the four nuclei which, in paramæcium, derive from the two first divisions of the micro-nucleus, three are destined for destruction. In like manner, during the maturation division which precedes the formation of the ovum proper, there are produced four cells, the large ovum abundantly supplied with protoplasm and three small abortive ova consisting only of nuclear substance with a very small quantity of protoplasm. Thus alike in paramæcium and in the metazoa the cell-divisions in question are not aimed directly at reproduction, but at a reduction of the hereditary equipment, at a halving of the number of chromosomes.

Presumably in both cases we are not concerned with something primordial, but with a phenomenon of adaptation. In the case of the ovum, the purpose of this adaptation is obvious. The ovum has, when fertilised, to develop into a new organism, which needs nutriment. For the fulfilment of this function it is essential that within its cell-body as much food-substance as possible should be stored up; especially seeing that in many animals, as for instance in reptiles and birds, the developing embryo is wholly dependent, until it emerges from the egg, upon the supplies of nutriment that are stored up within the shell. By the inequitable division into three small abortive cells, on the one hand, and a large ovum richly equipped with protoplasm, on the other, the total number of ova susceptible of development is, indeed, reduced to one-fourth; but the remaining ova, those that are still competent for fertilisation, are equipped with a much larger quantity of nutritive yolk for the needs of the developing embryo than they would have if an equitable division had taken place. Since in all animals many more ova and in all plants many more ovules are produced than will ever ripen, a reduction in the number of the ova does no harm to the species as far as its chances of preservation are concerned. For instance, the ovary of a new-born girl contains round about eighty thousand rudimentary ova of which, between infancy and puberty, about sixty-four thousand perish. But even from among the sixteen thousand ova that remain at puberty, if we assume the period of sexual maturity to last thirty years during which ovulation and menstruation occur regularly, only three hundred and sixty can be discharged from the ovary as fertilisable ova and make their way into the

uterus. Out of these three hundred and sixty, once more, only five or six will, on the average, be fertilised and developed into new human beings. In view of these considerations, it would seem biologically advantageous that of the four young ova formed in the process of maturation, three should perish and their stock of nutritive material be transferred to the surviving member of the four. But as regards paramæcium, we remain in ignorance why three of the four micro-nuclei formed in the process of maturation should perish. We can only note the fact.

Enigmatic at first sight is the third and last division of the surviving fourth micro-nucleus, for which we have no parallel in the maturation of the ova and spermatozoa of the multicellular animals. Presumably this last division is in some way connected with the bisexual character, with the hermaphrodism, of the slipper animalcule. It is plain that such division can only serve to detach the masculine migratory or fertilising nucleus from its feminine half, the stationary nucleus, since it is this division which renders the act of mutual fertilisation possible.

The attentive reader will have noticed a contradiction. Ostensibly, fertilisation should subserve reproduction and the multiplication of the species. In paramæcium, however, two members of the species conjugate, interchange parts of their nuclear substance, and separate without any multiplication having occurred. After conjugation, as before, there are only two animals, which then, just as before conjugation, continue to reproduce themselves by fission. Indeed, in some of the protozoa, conjugation actually reduces the number of individuals

by half. The two organisms that conjugate are not content with a mutual interchange of nuclear substance, but actually fuse their respective bodies to form one organism. To begin with, the cell-bodies flow together; then, each nucleus divides into four portions, three of which perish; whereupon the two surviving nuclei coalesce in a fertilising process. In many instances the conjoined individual thus formed rids itself of its cell-organs, assumes a spherical form, secretes a protective envelope, and passes for a shorter or longer time into a resting-stage. At length the envelope bursts, and thereupon the little creature, having emerged, subdivides to reconstitute two organisms. It is only the subsequent divisions which lead to multiplication.

We may, therefore, infer that the primary object of the conjugation out of which sexual life originated must have been to subserve the aims of heredity rather than those of reproduction. Its importance and easily recognisable significance is amphimixis—the interchange and the union of the heredity factors of two distinct individuals, this giving a greater capacity for variation, and increasing the adaptive faculty of the new living creature that arises from the act of fertilisation or conjugation.

A good many investigators are also inclined to suppose that long-continued asexual reproduction induces fatigue in the nucleus. They believe that reduction of the nuclear chromatin and the amalgamation of two nuclei in which such a reduction has taken place, effects a sort of rejuvenation whereby the animals concerned are given fresh energy for division. We know, indeed, that various protozoa, such as paramæcium and eudorina, can, in artificial cultures, reproduce themselves asexually

by fission for several thousand generations without the appearance of any signs of degeneration. Still, we have to take into account the possibility that laboratory conditions are more favourable than those which obtain in a state of nature, and that they enable the disadvantages of asexual reproduction to be surmounted ; or that a slackening of the capacity for asexual fission may, under laboratory conditions, not appear until after the lapse of a much longer time. When the protozoa in question are living in a state of nature, asexual multiplication is at regular intervals substituted by conjugation. Speaking generally, moreover, even in artificial cultures, fatigue manifests itself now and again after long periods of asexual fission, the cell-divisions occurring less frequently and taking longer than usual, until at length a sort of epidemic of conjugation sets in, to be followed anew by a long series of asexual multiplications.

Amphimixis will obviously best fulfil its purposes and most effectively promote the variability of the new individual when the heredity factors of the two members of a species entering into union are as different as possible—when the two partners in the love act derive from different strains. The nearer the kinship, the more closely will the hereditary equipments of the respective partners resemble one another, the less increase will there be in the variability, in the number of heredity units available for selection by the new individual in the course of its development, and the less, therefore, the increase in the capacity for adaptation. On the other hand, we may suppose that through a union of near kin, of a brother and a sister, of a mother and a son, of a father and a daughter, belonging to healthy families, there may be

born offspring who will be exceptionally vigorous, inasmuch as the favourable rudiments contained in the germ-plasm of the two parents deriving from the same stock will reinforce one another. Since, however, at any rate among civilised human beings and domesticated animals, hereditary taints or degenerative phenomena are present in almost every family, there is naturally great danger that, through the union of near kin, flaws will be accentuated.

For this reason nature sees to it that the union of near kin, or in the case of hermaphrodites a process of self-fertilisation, shall as far as possible be avoided. Where self-fertilisation or the habitual union of near kin occurs under natural conditions, this happens, as far as we are able to observe, chiefly when it is unavoidable, as, for instance, in the case of many parasites leading isolated lives, which are compelled to reproduce themselves by self-fertilisation or by the copulation of two individuals closely related. Obviously self-fertilisation or the union of near kin, even though it results in little or no enrichment of the hereditary equipment, is preferable to asexual reproduction in view of the rejuvenation of the nuclear apparatus it entails.

One of the manifold ways in which nature seeks to hinder the sexual union of near kin, in those species wherein the sexes are divided, is proterandria—the quicker development and the earlier development of sexual maturity in the case of male members of the species. The males leave their birthplace several days, or even several weeks, before the females of the same brood, and set out thus early on the search for mates. In such circumstances it is naturally most improbable

that a brother will conjugate with a sister. "Exogamy" will be the rule. Proterandria is customary in many insects, in which the males hatch out a week or so before the females. In frogs and toads, likewise, the males awaken from their hibernation and take to the water before the females, whose winter sleep lasts several weeks longer.

Among hermaphrodite organisms, animals as well as plants, proterandria is a frequent way of preventing self-fertilisation or self-pollenisation. Before the pistil of a hermaphrodite flower is fully developed and before the stigma is ready for the reception of a pollen grain, the anthers will have opened and scattered their pollen. We see the same thing in hermaphrodite animals in which the ripening of the spermatozoa precedes that of the ova, so that the bisexual creature functions first as a male and then as a female. In exceptional instances, on the other hand, we observe proterogynia, an earlier maturation of the feminine reproductive elements, which, of course, subserves a similar purpose. Still, there are exceptions to this, as to every rule, and we find organisms in which the male and female sexual elements develop simultaneously. Still, even then, as we shall subsequently learn, often enough nature has taken precautions to render self-fertilisation impossible or unlikely.

The "prohibited degrees" in our human marriage code subserve the same purpose. The danger of in-breeding explains why incest is so severely punished in almost all countries. Even among savages the conjugal union of near kin is often placed under a strict taboo, as we note especially in the case of the Melanesians. This is all the more remarkable seeing that these primitives are

still unaware of the connection between sexual intercourse and reproduction.

There have been and still are exceptions to this rule in the case of certain royal lines, witness the ancient Egyptians, the Persians, the Incas of Peru, and the contemporary Siamese and certain other Eastern civilised races. Among the Pharaohs of the Ptolemaic era and among the rulers of the eighteenth dynasty, brother-and-sister marriages were the rule, for only the direct descendants of the original stock were regarded as divine and as fitted to occupy the throne. Marcuse even believes that incest was the original type of human sexual relations; and it is unquestionable that most races, in their myths and sagas, refer their origin to a sexual union between father and daughter or brother and sister. Numerous experiments on animals show that in-breeding is not necessarily harmful. For instance, a hermaphrodite nematode, Diplogaster maupasi, has been reproduced for forty-six generations by self-fertilisation without any manifest injury. As regards savages, among the Baduvis, who inhabit the western part of Java, incest is regularly practised. For more than four centuries they have bred in and in, marriage always taking place between members of the same family, and yet they are still an extremely vigorous stock. In the case of our own thoroughbreds, incest is often practised, when the breeder wishes to accentuate some characteristic he favours.

In racehorses, speed is pre-eminently desirable; in milch-cows large udders are wanted and a maximum output of milk; the keepers of chicken-farms want hens that will lay very large eggs and as many of these as

possible. Fashion, too, plays a considerable part in such matters. Just as a stylish woman will one year be petticoated to the ankle and another to the knee, just as the crinoline will give place to the bustle and the bustle to the hobble-skirt, so must a lap-dog at one time have flopping and at another pointed ears, at one time a short tail and at another a long and bushy one. In other words, the breeder's object is to produce extreme types, and this can only be effected to the detriment of a generally harmonious development. The long and slender head of the greyhound means a reduction in the capacity of the skull and is therefore produced at the cost of the dog's intelligence. Biologically considered, pedigree animals are not the outcome of a higher development, but are simply degenerative forms which in a state of nature would speedily perish and can only be preserved as pseudo-species by the protective hand of man.

Besides, every experienced breeder knows that if he is to avoid the onset of grave illnesses and degenerations in his stock he must from time to time introduce fresh blood, even if it be at the forfeit to some extent of the qualities he wants emphasised. The pre-eminence of Europeans in mental and bodily achievements has certainly been promoted by the folk-migrations, by invasions, military campaigns, racial admixture, thanks to which the favourable heredity factors of many human subvarieties have been mingled. If the primitive Teutons had lived apart from other races, marrying only with one another, it seems probable that, had they not long since perished from degeneration, they would still be wandering in the forests equipped with no better weapons than stone axes and wooden spears. True though this be, a crossing

between races that are widely divergent, as between Asiatics and Africans or between Africans and Europeans, would appear to be harmful, and to result in the production of low-grade offspring. The injurious outcome of such crossings as that between the horse and the ass, or between animals still more remotely allied, manifests itself in the sterility of the hybrids.

It is time to return to our starting-point, the sexual behaviour of unicellular animals. We have seen that the cell-bodies of two distinct individuals can fuse completely, and also that the nuclei of conjugating organisms can unite after ejection of part of the nuclear substance. We may suppose this to have been the most primitive form of the sexual act in living creatures on the unicellular plane, and it seems likely enough that the process may have developed out of chance fusions occurring in the course of the prowl for food. When the two animals that fuse belong to different lines or strains, we have to do with a typical amphimixis. Often, however, we notice that a protozoon divides, and that, after fission, the two daughter-cells reunite as soon as reduction processes have taken place in their nuclei. Here there is no amphimixis, inasmuch as the hereditary equipment of the two daughter-cells and the hereditary equipment of the reunited cell are identical with that of the original cell before division took place. All that can be effected by such a process is some sort of rejuvenation of the nuclear apparatus. Sometimes, indeed, as for example in the flagellated infusorium Trichomastix lacertæ, which is parasitic in the hind-gut of the lizard, the cell-division above described does not take place. Merely the nucleus divides, the daughter nuclei thus formed move away from

one another towards the periphery of the cell, there pass through the reduction process with which we are already familiar, and then reunite to constitute a fresh nucleus. These two last methods of regeneration, technically known as autogamy and representing an extreme form of self-fertilisation, are altogether exceptional, and have perhaps originated in consequence of the parasitic life of these creatures. Speaking generally, in a sexual act we have a union between two members of the species which, though akin, belong to different strains.

A higher phase of development is reached in the behaviour of the slipper animalcules, for here, instead of a fusion of two organisms, a hologamy, we have an act of conjugation which consists of an exchange of male hereditary substance between the two cells. These organisms have not advanced to the level at which the sexes have been separated into male and female. We may think of paramæcia as unicellular hermaphrodites.

In certain other ciliated infusoria, however, in the beautiful bell-animalcules or vorticellinæ, a separation into male and female sexes characterised by well-marked bodily differences has been achieved, so that we can speak of a true sexual dimorphism. Vorticella has abandoned the free-swimming life of most of the ciliated infusoria, being fixed to a fragment of gravel or to the stem of an aquatic plant by a slender contractile filament proceeding from the posterior extremity of its body. Some species of vorticella live in colonies comprising a large number of individuals. Like all protozoa, the bell-animalcules reproduce themselves by simple fission ; but, from time to time, this asexual multiplication is interrupted by acts of conjugation. Certain members of a colony divide and

subdivide in quick succession, and the products of this subdivision do not (as in ordinary cases of simple fission) grow to the full size of adult vorticellæ. In aspect, likewise, they differ from their full-sized companions. The spiral crown of cilia which surrounds the mouth of the ordinary vorticella is rudimentary in these miniature specimens, whereas at the posterior extremity of the dwarfs there grows a circlet of cilia with the aid of which —having broken away from the stalk—they can swim freely in any direction. Such free-swimming dwarf vorticellæ are known as microgametocytes. They are usually regarded as males, but are really hermaphrodites with predominantly masculine characteristics. Having broken away from the colony, these dwarf males swim hither and thither until they encounter a normal female belonging to another colony. The dwarf vorticella attaches itself to the side of the female, the cell membrane disappears at the point of contact, and by degrees the male is completely absorbed into the body of the female. In the interior of the female cell-body there now occur processes exactly similar to those which occur in the cell-bodies of a pair of conjugating paramæcia that are connected only by a bridge of protoplasm. The macronuclei of the male and the female disappear ; the two micro-nuclei divide and subdivide to form, each, four micro-nuclei, three of which disappear by absorption into the cell-body. Thereupon ensues a third division, which results in the formation of the two stationary female nuclei and the two migratory male nuclei ; but now the migratory nucleus of the female partner and the stationary nucleus of the male partner likewise disappear, and only the migratory nucleus of the male and the

stationary nucleus of the female survive to unite in the process of fertilisation. As I have previously insisted, both the partners in this act of conjugation are still hermaphrodites, but in the larger of the twain the feminine type preponderates, the masculine function having been renounced ; whilst in the smaller of the twain the masculine preponderates, the feminine function having been renounced. Thus vorticella exhibits a transition stage between hermaphrodism and sexual differentiation. Out of the conjugation nucleus formed as above described there now arises, precisely as in paramæcium, the new, rejuvenated, normal nuclear apparatus. Inasmuch as in vorticella the act of conjugation is complete and lasting, we can already speak of it as true fertilisation.

Nevertheless, there is an important distinction between the sexual act just described and the fertilisation that occurs in multicellular organisms, in the metazoa. In these latter, copulation and fertilisation are distinct processes. Two complete individuals engage in the act of sexual reproduction, the male introducing sperm into the body of the female, or the male and the female separately discharging their reproductive products, the ova and the spermatozoa ; only thereafter does the act of fertilisation take place through a union between ovum and spermatozoon. In other words, there has occurred a severance of the reproductive cells from the somatic cells (the body-cells). In multicellular organisms, the sexual individual is merely the carrier of the reproductive organs, of the gametocytes, or of the reproductive cells or gametes. In the protozoa, on the other hand, which are unicellular, the sexual creature as a whole, as an individual, is simultaneously a sexual cell. In them, consequently,

conjugation and fertilisation, or sexual intercourse and fertilisation, are still identical.

In the metazoa, then, a remarkable step has been taken, the differentiation of the perishable body from the germ-plasm, from the reproductive cells which immortalise the life of the species. It is in pursuance of the division of labour that this evolution has occurred. The probability is that multicellular organisms developed out of unicellular ones through the formation of a colony consisting of cells which had undergone division and redivision without fully separating one from another. The first stage was the formation of such colonies as those of vorticella, in which the individuals remained close together, but still spatially separate. We cannot regard such a colony as a multicellular organism, inasmuch as there is lacking to it the chief characteristics of a unified organism, namely the division of labour, work done by an individual cell on behalf of a community of cells. In the spherical alga, Pandorina morum, a ciliated organism belonging to the family of volvocineæ, this advance to collective labour has already been made. Sixteen cells deriving from the division and subdivision of a primal cell remain connected in a little ball, jointly secreting a gelatinous investment in which the individual members of the colony are studded. Each of these sixteen cells is provided with a pair of cilia which project from the gelatinous envelope and, by their lashing movements, roll the little sphere over and over in the water. But in pandorina the individual members of the colony are of equal standing, each cell fulfilling the functions necessary to life, and each doing the same work for the community. The reproduction of the individual cells of the pandorina

colony occurs like that of the protozoa which live apart as single cells. By division and subdivision each cell of a colony produces sixteen cells. Thus within the original gelatinous envelope there have come into existence sixteen pandorina colonies each consisting of sixteen cells. Then the daughter-colonies are set free by the break-up of the maternal envelope. It is not easy to say what influence keeps the sixteen cells of such a colony so closely associated that they never exist as individual unicellular organisms, although they are manifestly endowed with all the capacities requisite for an independent monocellular life. Perhaps, as in the case of the feeding communities of the sun-animalcules, their co-operative life enables them to nourish themselves better ; or it may be that the conjoined cells are better able to resist enemies than they would be if they remained isolated. Anyhow, there is not as yet any division of labour, nor a severance into somatic and reproductive cells. The pandorina cell is still simultaneously a sexual animal and a sexual cell.

Another spherical alga, however, has definitively overstepped the boundary between monocellular and multicellular life. Volvox forms a colony which may consist of more than ten thousand individual cells arranged in a single stratum to enclose a sphere filled with a transparent viscid substance. In volvox as in pandorina, the colony is held together by a gelatinous limiting membrane. But, over and above this, the cells are interconnected by slender protoplasmic fibrils along which an interchange of cell-substance is continually taking place, so that the nutriment absorbed by one cell is distributed to the community at large. Still, these individual cells possess a

considerable independence. Each of them is equipped with a contractile vacuole, the simplest form of kidney; with green chromatophores; and with a pair of cilia. But the organism manifests a cell differentiation which does not exist in pandorina. Volvox has an anterior pole, a sort of "head", which forms the front when the organism is in motion; and the cells at this anterior pole are exclusively provided with reddish pigmentary spots, the most primitive form of an organ sensitive to light, of an eye.

Volvox remains capable of asexual reproduction, a group of its cells being able to produce daughter colonies by fission, just as one cell of a begonia leaf can grow into a begonia plant. But this asexual reproduction has passed into the background as compared with sexual production. Certain cells of a volvox colony, situated towards the posterior pole of the conjoined organism, are markedly distinguished in appearance and size from their fellows. These cells are the gametocytes, the rudiments of the male and female reproductive products. First of all the microgametocytes undergo considerable enlargement, and then, by numerous successive subdivisions, they form agglomerations each consisting of a hundred or more small cells, which undergo transformation into microgametes or spermatozoids, slender, thread-like bodies of about two micro-millimetres in length. Each of these spermatozoids has two cilia to propel it actively through the water. While the male sexual products are ripening, the macrogametocytes also begin to grow, and out of each macrogametocyte there is formed a macrogamete, a large cell abundantly supplied with nutritive plasma—in a word, an ovum. Thus in volvox the body

has undergone differentiation into an anterior, vegetative half, mainly concerned with movement and nutrition, and a posterior half consisting of reproductive organs.

The ripe sexual products are discharged into the interior of the colony, where fertilisation occurs. When the ova have been fertilised, they surround themselves with a tough envelope and remain inside the maternal colony until this dies and breaks in pieces. By division and subdivision of the ovum with a subsequent differentiation of the daughter-cells, new colonies are formed. After the discharge of its reproductive products, a volvox colony has lost the power of forming any new germ or sperm cells. It lives on for a time, but only as a sterile and purely vegetative organism. Soon signs of age manifest themselves, and the creature dies, just as the body of every multicellular organism dies sooner or later after the fulfilment of its supreme function, which is the production of ripe reproductive cells by whose union the perpetuation of the species is ensured. With the appearance of volvox on the stage of creation, with the severance of the body into somatic and reproductive cells, physiological death made its appearance in the organic world.

The processes described in the foregoing paragraph are characteristic of Volvox globator. In a kindred organism, Volvox aureus, sexual differentiation has appeared. One colony produces only ova, and is therefore female, whereas another produces spermatozoids, and is therefore male. Except as regards the difference in the reproductive organs, the male and female specimens of Volvox aureus are identical in appearance, sexual dimorphism not having yet manifested itself. Why, indeed, should the two carriers of gametocytes differ in

any other respect? The functions which the male and the female volvox have fulfilled are essentially identical. The female produces its ova and the male its spermatozoids; as soon as these are mature they are discharged into the water, and there the spermatozoids seek out the ova. The parental organisms take no active part in bringing the reproductive cells into contact one with another. It is not until a higher stage of evolution has been reached that the parental organisms come to play an active part in reproduction after the ripening of the germ-cells and the sperm-cells. In this higher phase of organic development, the male seeks the female, in order to discharge his spermatozoa as near as possible to the female; and of course reproduction is still more effectively assured when copulation takes place and the act of fertilisation ensues inside the maternal body. For this the female must have produced organs whereby the fertilised ova and the developing young can be protected at first inside and then outside her body; and this difference between the masculine rôle and the feminine leads, in the process of evolution, to the formation of extremely diversified organs, and often to a great difference in the aspect of the two sexes, to a far-reaching sexual dimorphism. In general, the male is the more active partner, seeking out the female to ensure the fertilisation of her ova, whereas the female remains passive, nay, is often obstructive. She tolerates or she resists. The difference between the sexes in the more highly developed multicellular organisms corresponds to the difference between the male and female reproductive cells. Already in paramæcium we saw how the migratory male nucleus sought the stationary female nucleus

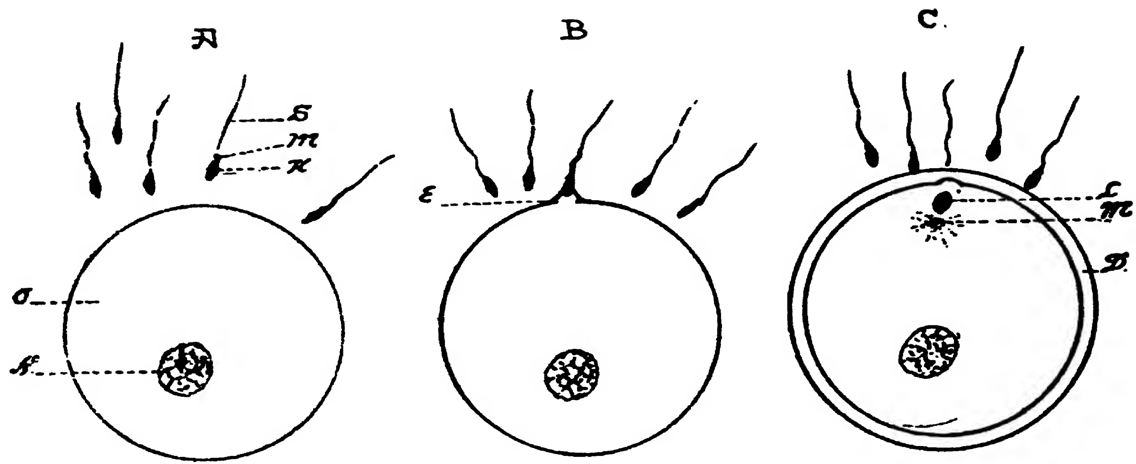


FIG. 7.—FERTILISATION.

K, head or nucleus of spermatozoon. M shank, out of which the centrosome is formed after the spermatozoon has penetrated the ovum. S, vibratile tail. O, cell-body or ovoplasm of the ovum. N, nucleus of the ovum. A, the great egg-cell or ovum, towards which five spermatozoa are swimming. B, the ovum has stretched forth towards the head of the nearest spermatozoon a protoplasmic process which is known as the receptive eminence, and through this the head of the spermatozoon will make its way. C, as soon as the spermatozoon has penetrated the ovum, the outermost layer of ovoplasm forms the vitelline membrane, which prevents the ingress of any more spermatozoa. The head of the successful spermatozoon has rotated through an angle of 180°, so that its shank is directed towards the nucleus of the ovum. We see that the shank has become detached from the head and is surrounded by radiations. It will move towards the nucleus of the ovum and coalesce therewith.

in order to amalgamate with it. Often enough the spermatozoa or spermatozoids have to traverse a long and dangerous road, on which countless mishaps may occur, so that the great majority perish, and only a few chosen specimens attain their goal, penetration of an ovum. All the same, the ovum is not quite so passive as might appear at first sight. Stationary though it be, it emits substances which exert a chemotaxic influence, which allure the male reproductive elements and show them the way. Furthermore, as soon as a spermatozoon is close at hand, the ovum relinquishes its attitude of ostensible indifference, stretching out towards the spermatozoon a protoplasmic process, the receptive eminence, into which the male reproductive element bores its way. (See Fig. 7.) Among all the animals with differentiated sexes, ranging up to mankind, the indifference, the inertia, of the female is only partial, and is in many cases a form of allurement rather than a defence. As we shall see in due course, coquetry (Eve's "reluctant, amorous delay") was not her original discovery, but has many prototypes in the animal kingdom.

CHAPTER THREE

HERMAPHRODITES AND INTERMEDIATE STAGES

WHICH is the original, the primary phase of sexual organisation, hermaphrodism or the existence of separate sexes ? This way of mooting the question is misleading. These are not necessarily simple alternatives. Both states may have developed collaterally and independently of each other. The designations male and female (the terms " active " and " passive " might just as well be used) are derivative expressions for a higher condition of development. In the slipper animalcule there exists only bisexuality, the active and passive elements of sex being united in the micro-nucleus, to separate temporarily in the course of conjugation, and to be promptly reunited after the interchange of the male element in both the conjugating partners. But among the protozoa, the infusoria already represent an advanced stage of development and are unquestionably separated from the lowest amœboid forms by as lengthy a series of historical evolution as are the fishes from the tunicate ascidians or the birds from the reptiles. If we assume, as the author has assumed, that sexuality arose out of the chance union of two individuals belonging to the same species but differing in some respects in their qualities, and that it developed out of this process because the exchange of individual qualities between the

members of the pair gave their offspring increased variability and capacity for adaptation and thus proved advantageous in the struggle for existence—then there may have been two lines of development: one taking the form of a separation, in any species, into two organisms having distinct sexes, the members of one sex being comparatively slothful and passive and the members of the other sex being comparatively active and questing, even though sexual dimorphism had not yet become apparent; and the other taking the form of the production of hermaphrodite organisms like paramæcium. The most important difference would be that in the case of the form in which the sexes became distinct one partner would have sought out the other, have fused with it, and have transmitted to it the heredity factors contained in its own (the active partner's) nucleus. When the sexes are separated we have to do with a one-sided giving and a one-sided reception, whereas in hermaphrodites, like paramæcium, the organisms give and receive, effect an exchange.

Along the line of a development into separate sexes, in which the members of the two sexes were at first remarkably alike, an intensification of this developmental trend would lead to the passive, slothful female members of the species storing up more nutritive material in their cell-bodies, whereas the more lively, more active, male partners would diminish in size but acquire more mobility. Hence would ensue a steadily increasing sexual dimorphism manifesting itself in the development of typical macrogametes and microgametes, of typical motionless ova on the one hand and typical actively motile spermatozoids on the other. This is what we see

in volvox and also in many of the sporozoa, such as the malarial parasite, and the coccidia, in which the development we are now considering has been pushed to an extreme.

But in the unicellular hermaphrodites we already observe a tendency towards a reseverance into two sexes. In vorticella, there have developed small motile forms which cut loose from their moorings, swim freely through the water, seek out their larger fixed congeners, and fertilise these. It is true that such microgametocytes or male vorticellæ are still equipped with the hermaphroditic nuclear apparatus we find in paramæcia, but the feminine rudiments remain functionless and perish during the act of conjugation, so that fertilisation is exclusively effected by the male portion of the sexual nucleus. The converse happens in the large female specimens of vorticella which remain attached by a stalk. In constitution these, likewise, are still both male and female, but in them the male part of the nuclear apparatus decays and only the comparatively torpid female nucleus receives the male migratory nucleus of the partner in the conjugal act.

Fundamentally, every organism that issues from a sexual act is in a sense hermaphrodite, for every male contains within his body a female, and every female contains within her body a male. That is to say, in every organism there are, primordially, latent the heredity factors of both sexes. Every fertilised ovum has a hereditary equipment which might enable it to develop into a male or a female or a hermaphrodite adult. The only question is whether the masculine or the feminine evolutionary tendencies shall greatly preponderate, or whether

both shall develop simultaneously and jointly, though perhaps in varying degrees. Even in the higher vertebrates, among which the sexes are very sharply distinguished, even among birds and mammals, our own species not excepted, we sometimes find in ostensible males or ostensible females that the developmental tendencies of the other sex have broken through in such a way as to lead to the development of partial or complete hermaphrodites.

This conception is not inconsistent with the fact that in the course of the fertilisation of the ovum the presence or absence in the fertilising spermatozoon of an X-chromosome, which is the sex-determining factor, decides (for the most part) whether the fertilised ovum shall develop into a male or a female. The heredity factors are not modified by this sex-determining fertilisation. All that happens is that the presence or absence of X-chromosomes decides whether the heredity factors promoting maleness or the heredity factors promoting femaleness shall gain the upper hand in the developing embryo. Whether a male be produced or a female, the heredity factors tending to promote femaleness in the former case, and those tending to promote maleness in the latter case are still present though they remain latent. The fact that the male organism contains rudimentary female vestiges, for instance, the uterus masculinus (see Fig. 8), and that in certain male mammals (the billy-goat, for example) this rudiment may develop into a typical uterus bicornis, or even in men may grow to an abnormal size ; or the fact that so manifestly virile an organ as the penis is regularly present in miniature form as one of the primary sexual characters of women and may occasionally

in a woman appear as a fairly large and well-developed penis capable of erection though imperforate (see Fig. 77)—these and many similar facts do not prove that human beings or other mammals have descended from hermaphrodite ancestors, but only that in the members

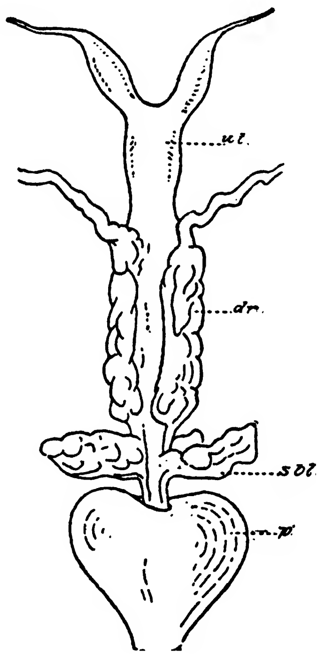


FIG. 8.—UTERUS MASCULINUS OF A YOUNG MAN.

p, prostate. *sbl*, vesiculæ seminales (paired). *dr*, enlarged and glanduloid distal extremities of the vasa deferentia. *ut*, uterus masculinus.

of each sex the developmental possibilities of the other sex are present, and may, occasionally, under exceptional circumstances, cease to remain altogether latent. (See Fig. 9.) This is very effectively disclosed by the hybridisation of two kindred species in both of which the sexes are markedly distinguished from one another ; for

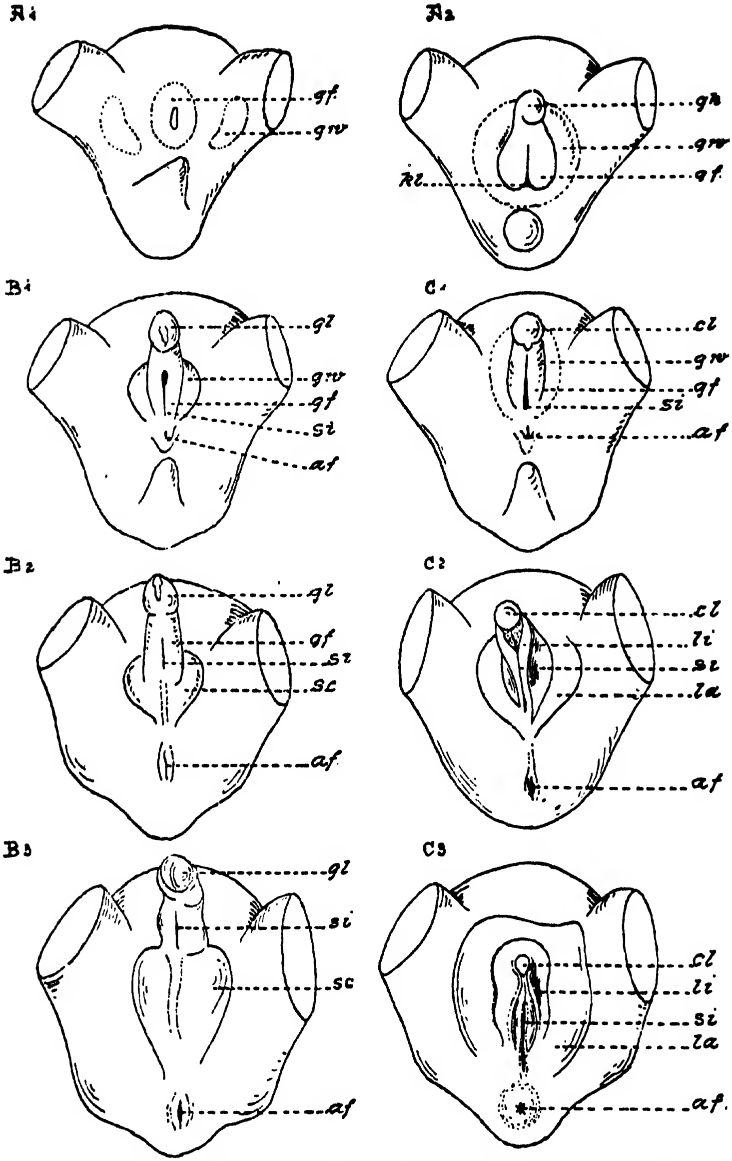


Fig. 9.—Development of the External Genital Organs in Human Beings.

Ai, Bi, B2, B3 are male embryos. A2, Ci, C2, C3 are female embryos. *gf*, genital fold. *gw*, genital eminence. *gh*, genital protuberance. *gl*, glans penis. *kl*, cloaca. *af*, anus. *si*, sinus urogenitalis. *sc*, scrotum. *la*, labia majora. *li*, labia minora. *cl*, clitoris.

instance, the cherry-moth, Biston hirtarius, and the apple-moth, Biston pomonarius. In Biston hirtarius, both sexes are normally winged moths ; but in Biston pomonarius only the males have well-developed wings, whereas in the females the wings are atrophic, so that no one but a skilled entomologist would recognise them as moths. If we cross a male hirtarius with a female pomonarius, the female offspring, as might be expected, are intermediate in form between the properly winged hirtarius father and the atrophic-winged pomonarius mother. They grow small lancet-shaped wings. Now let us reverse the experiment and cross a properly winged pomonarius male with a no less properly winged hirtarius female. If the manifest characters of both parents were to disclose themselves effectively in the offspring, the result of this crossing would be the development of properly winged moths ; but what we actually find is that the female offspring have the narrow, lancet-shaped wings of the hybrids of the former experiment. This signifies that the feminine gene of "abortive wing" which was latent in the chromatin of the pomonarius father has been awakened from its slumber by the act of crossing and has disclosed itself in the hybrid offspring.

Thus we see that in almost all classes of the animal kingdom hermaphrodism (bisexuality) and gonochorism (sexual differentiation) exist side by side, so that the members of the same species may develop, now into males and females, now into hermaphrodites. The little fresh-water polyp, Hydra viridis, one of the simplest structural forms of multicellular organisms, after it has reproduced itself for a number of generations by fission, will develop sexual organs, nipple-shaped spermaria or

testes appearing just below the ring of tentacles and, a little farther down, the spherical ovaries. But other specimens of Hydra viridis, living under precisely the same conditions, will develop only testes or only ovaries, having thus undergone differentiation into male forms and female forms respectively. In the closely kindred species Hydra fusca, the hermaphrodite stage seems to have been completely repressed, for when a phase of sexual reproduction sets in the individuals never produce both testes and ovaries, but an exclusively masculine or exclusively feminine developmental tendency discloses itself.

The mutability of the sexual trend is markedly displayed in another member of the hydrozoa belonging to the class of the marine scyphomedusæ, namely in chrysaora, in which we find, besides specimens that are purely male and specimens that are purely female, hermaphrodites as well; but even these hermaphrodites function in youth as males, then pass through a purely hermaphrodite phase, to develop subsequently into females.

Even in the highest branch of the animal kingdom, even among the vertebrata, sex is not necessarily determined for the whole of life. In young frogs we find, side by side with specimens which have genuine testes or genuine ovaries, invariably a number of specimens whose reproductive glands have an intermediate structure. These hermaphrodite specimens would seem not yet to have decided which developmental trend they will follow. Microscopical examination shows that the genital glands of these creatures contain, in addition to normal ovarian tissue, indifferent embryonic cells which, as the animal grows up, tend to an increasing extent to

develop into testicular tissue, the ovarian tissue simultaneously degenerating and perishing. In the case of the common frog of temperate climes, Rana temporaria, we find on the average among a hundred specimens, fifty-five females, twenty-one males, and twenty-four hermaphrodites. But whereas the percentage of females among older specimens remains approximately the same, the percentage of males steadily increases at the expense of the hermaphrodites, until at length these latter have completely disappeared, and, among mature frogs, the proportion of males and females is practically identical. This signifies that in the hermaphrodite specimens the feminine trend has been suppressed, that, metagamically, these young hermaphrodites have developed into complete males. Occasionally, however, in young hermaphrodite frogs the feminine sexual trend may gain the upper hand, the embryonic masculine reproductive tissue undergoing degeneration, the ovo-testis transforming itself into an ovary and the frog becoming a complete female. Always in these youthful hermaphrodite frogs one trend or other gains the upper hand in the end. We do not find any sexually mature hermaphrodites producing both ova and spermatozoa.

The sexual development of these frogs is influenced by environing conditions, by temperature, for instance. If we keep the tadpoles in water at an ordinary room temperature (somewhere about 68° F.), approximately half of them develop into males and half into females. A considerable reduction in the temperature of the water, which leads to a marked delay in the development of the tadpoles into frogs, tends likewise towards the development of females, so that even in the reproductive glands

that were originally intended to become testicles ova begin to appear at the periphery. An increase of temperature has the opposite effect. The animals originally destined to become males continue their development in the masculine direction and form normal testicles, but in addition the ovaries of those specimens which at lower temperatures would have become females show an inclination to transform themselves into testicles. This trend towards masculinity may become so strong that, among adult frogs, females are altogether lacking. Presumably, metabolic and nutritive processes account for these respective changes. Increase in temperature accelerates tissue-change, whereas decrease in temperature favours the storage of nutritive material. For this reason the animals kept unduly warm suffer from retarded growth, whereas those which are kept unduly cold manifest an excessive bodily development. In the animals kept at a higher temperature than the average, there is, so to say, a lack of surplus nutriment to provide for the formation of the ova, which demand considerable quantities of highly nitrogenous matter for their yolk, so that the spermatozoa, whose claims are less exorbitant in this respect, tend preferentially to develop; whereas, conversely, the enhanced assimilation which occurs when the temperature is artificially lowered favours the formation of the female reproductive elements. We know that, speaking generally, unfavourable environmental and nutritive conditions tend to favour the origination of males.

Toads occupy a peculiar position in the matter of sex. In these creatures there are no pure males, but only pure females and hermaphrodites which function as males.

For a long time biologists have recognised both in female and in male toads the existence of what is known as Bidder's organ, which is perched upon the anterior end of the testicle or ovary as the case may be, and which undergoes marked seasonal variations in size and development, above all in males. In female toads, Bidder's organ remains rudimentary, and commonly atrophies with advancing years. Only in male specimens does it attain its full development and remain intact throughout life. Bidder's organ is, in fact, an atrophic ovary which in normal circumstances remains functionless. In the spring, it is small and wrinkled, but gradually enlarges as summer comes on, until in July or August it is larger than the testicle. In its interior at this season there goes on a vigorous multiplication of the germinal epithelium, numerous ova developing, which grow to a respectable size, but remain functionless, to disappear in the autumn. Summer after summer, the process is reiterated. If, however, in one of these male hermaphrodite toads, we excise the testicles, Bidder's organ begins to grow vigorously, and year after year produces ova in continually increasing numbers, until, after the lapse of about four years, it has become transformed into a normally functioning ovary. At first after the operation the animals retain their external and internal masculine characters; but the more advanced the transformation of Bidder's organ into an effective ovary, the more conspicuous is the disappearance of the male sexual characters. The thumb-callosities, the remarkable clasping organs with which the hermaphrodite-male toad embraces the female during the act of copulation, undergo atrophy; the slender, pointed head grows wider and more obtuse;

and the clasping instinct (which is so strong that these hermaphrodite-males in the rutting season will, if they cannot find a female, mount and clasp another male and even a dead toad) disappears. Furthermore, the vestiges of the Müllerian duct, which remains in every male, of the duct which in the development of the female toad becomes transformed into the oviduct, becomes in these castrated males a typical oviduct with a uterine sac and accessory glands. In a word, the effect of the excision of the testicles has been, in due course, to transform what appears to be a male into a normal female, capable of normal heat.

Even without artificial removal of the testicles, and under natural conditions, we sometimes note such a development of Bidder's organ into a normal ovary, this being accompanied by the development of female excretory passages for the reproductive cells. In such cases we have genuinely hermaphrodite toads which can function simultaneously as males and as females.

Still more remarkable is the belated transformation of one sex into the other which may occur in a fish known as the sword-tailed minnow, Xiphophorus Helleri. In these beautiful creatures, which belong to the carp family, the sexes are markedly differentiated. They owe their name to the fact that in the males the lower segment of the caudal fin has been prolonged into a sword-shaped process which serves as a sexual lure during the amatory play of the pair. The female lacks this process. Sexual dimorphism is marked in other respects, the body of the male being narrow and slender, that of the female plump. When mating has taken place and the development of the young has begun, there appears in the females on

the side of the body above the ventral fin a dark pigmentation, the so-called puberal or gestational macule.

When such a fully developed female has several times in succession brought living young into the world, strange transformations occur in her body, inaugurated by a paling and ultimately by the disappearance of the gestational macule. Simultaneously the lower segment of the caudal fin begins to grow and transforms itself into a masculine sword-process. This outward transformation is accompanied by phenomena of decay in the ovaries. The ova of varying degrees of ripeness that remain in the ovary degenerate, so that only the germinal epithelium remains. After a time the cells of the germinal epithelium, which have been in a resting-stage, begin to divide once more, whereupon the young cells develop, not into ova, but into typical spermatozoa. What was a female has metamorphosed itself into a genuine male, with all the male characters and instincts, differing from a primary male specimen only in respect of size and plumpness. Just like a normal male, the transformed creature now seeks out a female, woos it in love-play, fertilises it, and becomes the father of a new generation. But the offspring of such a male which was primitively a female and procreates in conjunction with a normal female are always females. This depends upon the constitution of the chromosomes, a matter into which we cannot go more fully here.

The remarkable transformation above described may occur not only in older females which have already borne young but also in virgin females. Whether the offspring of such a masculinised female (themselves, as aforesaid, all females) are capable of a like transformation, or whether

in them the feminine developmental tendency is fixed, is still unknown.

We have learned that environing conditions (temperature, diet, etc.) may exert a far-reaching influence in the development or transformation of the reproductive apparatus. According as conditions vary, there may arise, in certain species, fully developed hermaphrodites or sharply distinguished males and females ; and when there is a rhythmic change from hermaphrodism to differentiated sexuality and back again, we speak of an alternation of generations.

We sometimes find as parasites in the lungs of frogs great numbers of the nematode worm Rhabdonema nigrovenosum, which grows to nearly an inch in length. Although nematodes in general have distinct sexes, the parasitic rhabdonemata are typical hermaphrodites, proterandric hermaphrodites, the male reproductive cells ripening before the ova. A parasitic life tends to favour the development of hermaphrodism. Many other examples could be given to show how species which have adopted the parasitic mode of life develop into hermaphrodites, although closely kindred species living in a free state have distinct sexes. In this respect parasitism resembles a fixed as contrasting with a migratory existence in favouring the onset of hermaphrodism. The biological value of the adaptation in such cases is obvious. When animals have become parasitic (I refer especially, of course, to internal parasites), just as when, without being parasites, they have abandoned the migratory life which is generally characteristic of the animal kingdom and have become attached, as are most plants, the likelihood of fertilisation is greatly increased by the develop-

ment of hermaphrodism, which may take the form of self-fertilisation. There are, indeed, exceptions. We know of instances in which the members of a parasitic species have separate sexes whereas their free-living cousins are hermaphrodites.

Unfortunately we still know too little of the determinants of hermaphrodism on the one hand and a separation of the sexes on the other, to formulate strict laws regulating this matter. The experiments already described concerning sexual transformation in frogs under the influence of heat or cold show that a change in external conditions during the period of growth may play a part here—that external stimuli count for something in the process. It is certain to-day that the determination of sex is not effected exclusively and once for all during the act of fertilisation.

One of the most remarkable instances of a deferred metagamic determination of sex is seen in the remarkable organism Bonellia viridis, which abound in the Mediterranean and on the Atlantic coasts. (See Fig. 10.) The vivid green colour of bonellia is by itself enough to attract attention. It was formerly supposed that, as in the case of Hydra viridis, this colour was due to symbiotic algæ, but it is now known to depend upon a green pigment produced by the creature on its own initiative. Above all, however, bonellia is notable for its far-reaching sexual dimorphism. The body of the female consists of a muscular sac, sometimes spherical and sometimes ovoid, four or five inches long. From this there projects a sort of proboscis which may stretch to a length of twenty inches or more, ending in a mouth which opens between cephalic lobes. The males, on the other hand, are tiny

creatures whose dimensions can only be given in millimetres. From the ova of bonellia there develop free-swimming larvæ, propelled through the water by means of cilia. When such a free-swimming larva comes into contact with an adult female, it attaches itself to the

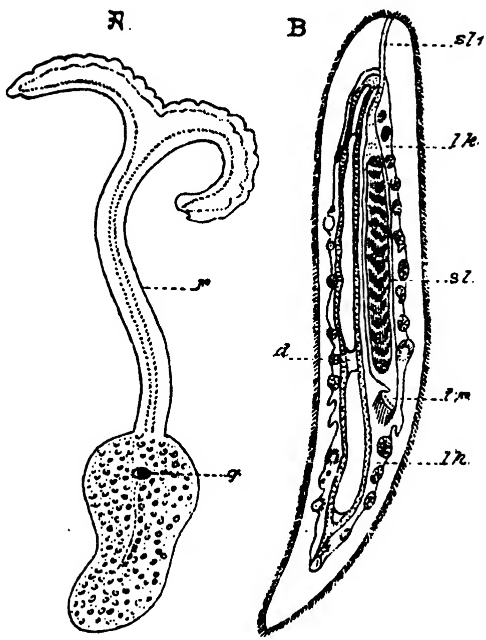


FIG. 10.—BONELLIA VIRIDIS.

A, female (moderately reduced). B, dwarf male (magnified forty diameters). *r*, proboscis. *g*, sexual orifice. *d*, gut. *lk*, body-cavity with packets of spermatozoa. *sl*, seminal duct. *tr*, seminal infundibulum. *sli*, excretory orifice of the seminal duct.

proboscis and begins to grow into an adult worm. After crawling up and down the proboscis for a time, it makes its way through the mouth into the gullet of the female and here completes its development to become a mature male. It is now ready to migrate once more to the outside of the body of the female, when it crawls up the

proboscis to reach the sexual aperture of the female (see Fig. 10), into which it makes its way. In the vagina of a female bonellia we may find as many as a dozen of such dwarf males, which, apart from showing their gratitude by fertilising their female host, live on her as parasites—and for a long time, before they were recognised as the males of the species, they were actually regarded as parasites.

But the strangest point of the story remains to be told. The ciliated larvæ that grow out of the fertilised ova are, to begin with, perfectly neutral in the sexual respect. They will not necessarily develop into the minute male form of adult organism, for their germ-plasm also contains the rudiments requisite for the production of the huge female. Chance, or the instinct of the larva, determines its fate. If instinct is at fault, if the creature in the course of its migrations should fail to discover a female on whose proboscis it can settle down, it must abandon the hope of becoming a member of what we are accustomed to speak of as the stronger sex. Inevitably, in that case, it develops into a female, its sex being wholly determined by whether it does or does not attach itself to the proboscis of an adult female.

What is the explanation of these remarkable facts? For a long time science was confronted with what seemed an insoluble enigma, but the researches of recent years into the nature and effects of the substances known as hormones have cleared up the mystery. It seems plain that substances of a hormonal nature secreted by the epithelium of an adult female's proboscis and absorbed by the larvæ that implant themselves upon this organ must inhibit the development of the feminine rudiments

and stimulate the trend towards masculine development. We find that this inclination towards masculinity can only take full effect when the larva has spent a considerable time upon the proboscis of the female, when it has been exposed for a sufficient season to the hormones produced by the epithelium of the adult female. If the larva be removed within twelve hours after it has settled down upon a proboscis, the effect of the hormones has been so small that the creature can still develop into a normal female. If, on the other hand, the larva has lived more than forty-eight hours upon the proboscis, it always develops into a perfect male. Larvæ detached more than twelve hours and less than forty-eight hours after they have settled down upon a proboscis grow into hermaphrodites in which the masculine or feminine characters predominate to a varying degree, the extent of masculinity being directly proportional to the time which the larva has spent upon the proboscis of the adult female.

From the dried proboscis of a female bonellia, extractive substances can be prepared, and young, still undifferentiated larvæ can be induced to develop into males by subjecting them to the influence of these extractives. The extractives from the dried proboscis, however, take longer to produce such an effect than does fresh proboscis juice. It is clear that the substances in question must modify the balance of nutrition in the larva, just as heat does in the case of immature frogs (tadpoles), with the result that the body of the youthful larva is deprived of the power of manufacturing or absorbing the substances requisite for the development of a feminine organism (whose nutritive claims are more exorbitant), and can

therefore only grow into the less exacting male. There is direct evidence to show that metabolic processes play a notable part in the conspicuous metagamic sex-determination. If we rear a number of free-swimming larvæ in a culture-glass in which they have an inadequate supply of nutriment, we find that a considerable proportion of them develop into females after the normal fashion of larvæ which do not succeed in establishing themselves upon the proboscis of an adult female of their species; but that a good many of the growing larvæ exhibit a marked tendency to hermaphrodism, and that some of them even grow into typical males. Since larvæ brought up under identical conditions show such differences in the course of their development, we are compelled to assume that the sexual tendency towards maleness must vary in strength from individual to individual, so that, despite the fact that they all seemingly have the same hereditary equipment, the dominance of male and female genes must be subject to oscillation.

Further evidence that under-nutrition inhibits the development of femaleness and favours the development of maleness is furnished by the growth of the larvæ of the copepod crustacean Monstrilla danæ. These larvæ are parasitic in the blood-vascular system of an annelid. In the same host there may be one, two, or several larvæ. If there are several parasitic larvæ in one host, then all the larvæ develop into males. If the annelid harbours only one larva, so that this latter has ample space and an abundance of nutriment, it has an equal chance of developing into a male or a female. Never, as yet, have two female monstrillæ been found to develop in the same host. Manifestly, the females make so extensive a call

upon the food resources of the host that should there be more than one larva it is impossible for them both to develop into females.

Additional proofs that a change in environing conditions may in course of time modify sexual organisation and lead to the production of hermaphrodites among creatures in which the sexes were originally distinct have been furnished by observations upon the great fresh-water swan-mussel, Anodonta cygnea.

In our rivers and streamlets, where the water runs freely, hermaphrodite swan-mussels are scarcely ever found, but in backwaters, where the water is stagnant, hermaphrodites tend more and more to predominate. Fifty years after a loop has been closed by a dam, so as effectively to check the flow, hermaphrodite swan-mussels will greatly outnumber the specimens showing clearly distinguished masculine and feminine characters. The biological explanation is the same as that which accounts for the frequency of hermaphrodism among parasites and animals that have adopted a permanently fixed habitat, namely, that hermaphrodism favours the chances of fertilisation in such cases. Male swan-mussels discharge their sperm into the water, and naturally when the water is flowing the spermatozoa are more likely than when it is stagnant to make their way into the gill-cavity of a female so that they can fulfil their vital task of fertilisation. In stagnant water, since the males are incapable of seeking out the females, many of the latter will remain unfertilised, whereas when the mussels are hermaphrodites self-fertilisation can be effected in case of need. Furthermore, by the transformation of the individual specimens into hermaphrodites

the masculine and feminine sexual components are doubled in number.

Let us return, however, after this digression, to the parasitic nematode in frogs' lungs. It is there that the fertilisation of the ova of rhabdonema takes place. When the young worms have sufficiently developed, they migrate from the lung into the œsophagus of the host, pass down the intestine, and are expelled amid the fæces. In the course of a few days they develop into sexually mature males and females of what is known as the rhabditis form, which is much smaller than the parasitic hermaphrodite generation. After the rhabditis worms have coupled, there develop within the interior of the fertilised female from two to four embryos. These little cannibals and matricides proceed, as they grow, to devour their mother's body from inside, until at length the young worms lie as it were in a cocoon within her exoskeleton. At length the investment bursts, the young worms escape, and, if they are lucky enough to be swallowed by frogs, they creep into the hosts' lungs and develop there into specimens of the hermaphrodite generation, which, as already said, are larger than the worms that pair in the open. With the parasitic hermaphrodites, the developmental cycle begins anew. This is a good instance of what is meant by the alternation of generations.

Very remarkable reproductive conditions can be studied in some of the polychæte chætopod annelids. These animals have a high capacity for regeneration, and therefore multiply by budding or by fission as well as by sexual reproduction. Fission is preceded by the formation of the most important organ-rudiments of the new individual that is to be split off, and these new formations go on so

rapidly as to lead to the transient existence of long chains of worms or of branch colonies. Since in many of the chætopods the head is furnished with large eyes, long antennæ, and other appendages, the first impression produced by looking at such a chain of worms is that the hinder worm is in the act of swallowing his front-rank man.

Generally speaking, the polychætes have separate sexes, but in many of the families of this order (among the syllidæ, for instance) we find veritable hermaphrodites. The syllidæ are marine annelids, some of which inhabit depths of nearly ten thousand feet. Several species of them have taken up their abode within the bodies of glass-ropes (hyalonemata), siliceous sponges attached to the sea-bottom. In Syllis corruscans, among others, the hermaphrodite character is manifest at the first glance. The body of the worm consists of two sharply distinguished sexual regions, the anterior, dusky portion containing the female reproductive organs, and the hinder part, which is of a vivid orange-red tint, containing the male sexual organs. Suddenly, however, the male part will detach itself from the female, will grow a head of its own, with large eyes and feelers, thus becoming completely independent. We see that even an organic marital bond can be severed! By division a hermaphrodite organism has produced a distinctive male and a distinctive female, and the fertilised ova of the latter grow into new hermaphrodites. Once more we encounter an alternation of generations.

In the sexually differentiated Bonellia viridis, we made acquaintance with dwarf males that lead a parasitic existence within the sexual organs of the female. On the bodies of hair-stars and sea-lilies, echinoderms of the

crinoid order (fossil representatives of which are found as early as the Cambrian formation), we often see tiny parasites belonging to the genus myzostoma. The members of the largest species, which bear the proud name of Myzostoma gigas, are less than a centimetre long. There was considerable dispute as to which class of the animal kingdom these minute creatures belonged. They are flat; they have finger-shaped appendages projecting from either side of the body; they crawl about on rudimentary feet beset with chitinous hooks and bristles, and they also have suckers with which to cling to their host. Some biologists class them as trematodes; others place them among the scolopendræ; while yet other authorities regard them as more akin to mites. However, it is now generally agreed that, as Metschnikoff believed, they are polychætous annelids.

The soft upper surface of these creatures, which are often of a motley colour, is thickly beset with cilia. In myzostoma (as in bonellia) there were discovered upon the bodies of the females of the species, in the vicinity of the reproductive orifice, a much smaller animal of the same kind clinging fast. "Aha!" was the natural thought, "a dwarf male!" In actual fact, however, among the myzostomids there are neither males nor females, the animals being true hermaphrodites, maturing first as males and subsequently as females. The sexually undifferentiated immature worm becomes, to begin with, an effectively functioning male, whose female reproductive glands are still in an embryonic state. Then, after myzostoma has performed its duties for awhile as a male, it grows much larger, changes its shape, while its female reproductive organs mature and its male repro-

ductive organs atrophy. When this phase of feminine maturity has been achieved, myzostoma appears to be purely female. Thus a well-marked sexual dimorphism is stimulated by what is only an alternation of sexual development in the same individual. What appears to be a dwarf male is really a youthful hermaphrodite functioning for the time being exclusively as a male. At any rate, that is what happens in the case of Myzostoma pulvina, although in some species of myzostoma these reproductive phases may overlap.

A still more conspicuous example of such a transformation of a hermaphrodite male form in youth into a female form at a maturer stage of development—a change accompanied by comprehensive organic transformations affecting the whole body—is supplied by a small crustacean, Danalia curvata, classed among the isopoda. This animal, apart from its sexual peculiarities, is unique (so far as our present knowledge goes) inasmuch as it is parasitic on another crustacean which is itself parasitic in a third crustacean!

To begin with, the larvæ of danalia develop into what are called epicardium larvæ, which are still sexually indifferent, and which, in adaptation to their coming parasitic life, are equipped with piercing maxillary palps. It has thirteen pairs of well-formed appendages, and the terminal segment of the thoracic appendages is equipped with hook-shaped claws resembling the chelæ of a lobster from which the smaller joint has been broken away. These larvæ swim freely about until they encounter a pelagic copepod. With its claws, the larva clings to the host, thrusts its sucking maxillary palps deep into the body of the latter, and nourishes itself upon the copepod's

body-juices. After several moults the epicardium larva has become a sexually mature male, the so-called cryptoniscium larva. During these moults the body has considerably increased in length, the legs have been transformed into swimming appendages, large eyes have grown on the head, and in the interior of the body there are two large and active testicles, each with a spermatic duct leading to a joint orifice. Now the parasitic life is abandoned for a time, the male danalia quits his host and swims away to find a sexually mature female danalia, with whom he pairs.

But whereas in the case of most animals the attainment of sexual maturity signifies the completion of bodily development, with our young danalia this is by no means the case. As soon as the creature has fulfilled his duties as a male he sets out in search of a fresh host upon whose body-juices he can feed. This time the copepods are spared. The next victim is to be a Sacculina carcini, a crustacean of a different kind, belonging to the order of rhizocephala. But since sacculina is itself parasitic within the body of another crustacean, the crab Carcinus mænas (whose tissues sacculina interpenetrates with a thick web of sucking tubes), the first onslaught of the cryptoniscium larva must be made upon this secondary host, to whose body the danalia clings with his two modified, hook-shaped thoracic appendages. While attached in this way to the body of the crab, the danalia undergoes a new moult, in which the larva rids itself of all its appendages and retrogresses into an elongated, unjointed sac. Only the eyes and the oral apparatus, a sort of piercing proboscis, are retained. With this proboscis the larva bores into the body of the crab until the

instrument encounters the sucking web of the sacculina, from which, thenceforward, it derives its own nourishment. The cryptoniscium is thus not directly interested in the crab to which it has attached itself, but only because this is the involuntary host of a sacculina.

The reversion which began with the first moult goes further. The eyes, the nervous system, and the muscular system, which are no longer needed now that the creature has become fully parasitic, degenerate or completely disappear, while the intestinal tract with its digestive glands undergoes development. The testicles, likewise, are affected by these degenerative processes, which culminate in the complete disappearance of the organs. In their place, ovaries grow. These already existed in the sexually mature male as rudiments situated above the testicles, but they now develop into conspicuous tubular structures, each of which has two laterally disposed oviducts. Thus what was in youth a male organism has, by way of an intermediate hermaphrodite stage, been transformed into a female. But the developmental process is not yet finished. After pairing and fertilisation have taken place, the maternal organism makes provision for the safety of the embryos. There is formed a sort of uterus which, as the brood grows, gradually displaces the other organs, until at length the whole distended maternal body becomes little more than a bladder filled with eggs.

Inasmuch as the change from the young male form into the mature female form is accompanied by a marked increase in size, there is so conspicuous a sexual dimorphism that, had not the whole process been watched, no one would ever suppose that two types so different were members of the same species at varying ages.

As regards the problem of a complete change of sex in the same individual, the problem with which we are here concerned, the life-history of sacculina and the effects of its parasitism upon the crab which is its host are, perhaps, even more interesting than what has already been said about danalia. The free-swimming larval form of sacculina is a typical crustacean larva which does not differ in any notable respect from the early stages of its non-parasitic congeners. Not until its parasitic existence has begun do there occur those extensive transformations which would make it impossible for anyone who had not watched them to suspect the adult sacculina to be a crustacean at all. When, after several moults, the free-swimming sacculina larva has reached what is known as the cypris stage, it attaches itself to the body of a crab belonging to the species Carcinus mænas which is three or four months old, rids itself of all its appendages, discards considerable portions of its body, and transforms itself into an unsegmented sac. Simultaneously most of the internal organs, with the exception of the reproductive glands, degenerate. From this sac there grows a process which bores through the chitinous exoskeleton of the host in one of the soft intersegmental regions. Through the aperture the sacculina larva makes its way into the body-cavity of the crab, settling down beneath the latter's intestinal canal. Thus the external parasite has become an internal parasite. The process which had originally perforated the exoskeleton of the host branches and re-branches until its ramifications ultimately envelop all the internal organs of the carcinus except those absolutely indispensable to life—the heart, the gills, and the nervous system The carcini in which sacculini have established

themselves become somewhat sluggish in their movements, but do not in other respects differ much in appearance or in vital manifestations from those which harbour no parasites. The moults which are indispensable to the growth of the crab occur at the regular intervals. After the sacculina has been an endoparasite for about twenty-two months, it becomes sexually mature. Thereupon it resumes the life of an external parasite. The greater part of its body is extruded beneath the abdominal region of the carcinus, only the ramified tubes essential to its nourishment remaining within the body of the host. After the sacculina has become an ectoparasite once more, the carcinus ceases to moult, and, penned within its cuirass, it can no longer grow. The sacculina, which is now about two years old, discharges its male and female reproductive elements into the water. It lives about fifteen months longer as a sexually mature animal, engaged in the work of reproduction. At the beginning of the fourth winter it dies, and its host is freed from the tormentor. As long as the sacculina remained an endoparasite, the host showed little sign of suffering from its presence. But with the resumption of the sacculina's ectoparasitic life, when the reproductive cells begin to develop, the parasite withdraws from the carcinus such a large amount of nutritive material that the latter crustacean suffers seriously from under-nutrition, and finds it difficult to carry on even a vegetative life. Its reproductive organs, ovaries or testicles as the case may be (for carcinus has distinct sexes), are gravely affected as well as the other organs, and may be completely destroyed. In a word, the parasite has castrated its host. Everyone knows that when our domestic animals are gelded,

especially when the removal of the reproductive glands is effected in early youth, the growth of the castrate is profoundly affected, so that what should be a masculine body is in large measure feminine, and the secondary sexual characters fail to develop properly. We see the same thing in a male carcinus which has been " castrated " by a sacculina, for its appearance comes to resemble that of the female crab. The great convex pincers of the male become flattened and are comparatively small ; the narrow abdominal region grows long and wide ; the front pair of abdominal appendages, which are tubular and serve for the transmission of the semen, atrophy. On the other hand, the other abdominal appendages assume the two-branched feminine form suitable for carrying ova. At length, as far as outward aspect is concerned, it becomes impossible to distinguish such a castrated male from a female carcinus.

Nor is this transformation restricted to the secondary sexual characters. The testicles and the seminal ducts undergo regression, so that, in extreme cases, the merest vestiges of them remain. In female carcini which harbour sacculinæ, various involutionary phenomena likewise manifest themselves, but these are never so striking as in the male. Still, the internal reproductive organs of the female may undergo almost complete atrophy.

When the sacculina has died and has become detached, the carcinus which has harboured it gradually recovers, and regenerative processes set in. The females reconstitute normal ovaries and oviducts, so that they become fully equipped females once more. The males are less fortunate ! In them, also, the remnants of the germinal epithelium begin to regenerate, but instead of this leading

to the development of testicles (as we might expect in the case of animals having such sharply differentiated sexes, so well marked a gonochorism), there ensues the production of typically hermaphrodite glands, ovo-testes in which both spermatozoa and ova mature. Not only are the seminal ducts regenerated, but side by side with them oviducts are formed. Thus a crab which was primarily a male has become a true hermaphrodite, able to function equally well as a male and as a female.

Here, once again, we have a striking demonstration of the fact upon which we have insisted more than once, that even in species whose sexes are clearly differentiated, both the males and the females have latent in their germ-plasm the rudiments of the qualities which appear specific to the opposite sex. Normally, the monosexual developmental trend predominates so markedly that the rudiments of the opposite sex manifest themselves only in a sketchy and fragmentary way. Nevertheless, a disturbance in the body-chemistry may arouse the activity of these repressed rudiments, thus leading to the development of a more or less extensive hermaphrodism or even to a complete change of sex. Herein, moreover, lies the explanation of the psychical metamorphosis, thanks to which a masculine sexual impulse may be transformed into a feminine or conversely, as we see in male homosexuality and in lesbianism. Such " perversions " are not confined to the human species, being common enough in the realm of the lower animals.

We have hitherto been considering organisms at a comparatively low level in the scale. Even more astonishing are sexual transformations when they occur at a higher level in the animal kingdom, in birds, for

instance. As regards these there has been recorded a fair number of instances as to which the evidence is unexceptionable. For four years an Orpington hen had behaved as a respectable hen should, laying eggs and hatching out her chicks. Then she fell sick for a time, and, after her apparent recovery, she exhibited a remarkable change. She began to crow, somewhat timidly at first, but soon louder and louder ; she developed a cock's comb ; spurs grew on her legs ; her plumage changed into that of a male bird ; until, after a year had elapsed, this sometime hen looked like a typical Orpington cock. But she did not only look like one, she behaved like one. She trod hens, and, while doing so, discharged seminal fluid. Penned with a young hen which had never before been trod, she paired with this virgin spouse, and from the latter's eggs there actually hatched out two chicks. A bird which for four years had functioned as a hen had, in the fifth year of life, undergone metamorphosis into a thoroughly effective cock.

I have already said that as a prelude to this remarkable transformation the hen had been ill. A post-mortem examination of the body of the cock into which she had developed showed the bird to be gravely affected with tuberculosis, the ovaries and oviduct in especial having been completely destroyed by the tubercles. Since she now lacked vital energy sufficient for the regeneration of the female reproductive glands, in place of these the latent, less exacting, male germinal rudiments developed, and, *pari passu* with the growth of the internal male reproductive organs, the external feminine secondary sexual characters became completely masculinised, so that there was an entire change of sex. Once more we

learn from this instance that unfavourable environmental conditions, disturbances of metabolism, tend to inhibit the factors of feminity and to favour the activity of masculine rudiments. At the Sorbonne a sum of ten million gold francs is held in trust, this having been a prize offered more than a century ago by an eccentric to the first man who became pregnant. We see, however, that what appeared to be no more than a cobweb spun by a diseased brain is, in fact, a theoretical possibility.

It will be necessary at a later stage of our investigation to return to this problem of the transformation of sex.

As among the vertebrates, so among the insects, sexual differentiation is well marked. We know among insects only one instance of genuine hermaphrodism, which is met with in the remarkable wingless fly termitoxenia, a welcome guest among the communities of an Indian species of termite, Termes obesus. All the same, termitoxenia does not treat its host with much consideration. Ordinarily the flies live in that part of the nest in which the termites deposit their eggs, for the flies feed upon the eggs, piercing them and sucking out their contents. The termites, which in general are pugnacious creatures and fiercely attack any intruder into their nest, have a good reason (perhaps it would be better to say an adequate reason) for tolerating the presence of these egg-devouring termitoxeniæ, and even for making them thoroughly welcome. "Vice" is not a peculiarity of civilised men. Being a product of social life, it is characteristic also of these community-forming insects, which are a prey to the delights of intoxication. On the abdomen of termitoxenia there are glandular filaments secreting a fluid which appears to contain a "habit-

forming drug". At any rate, it is passionately consumed by the termites.

Termitoxenia is a true hermaphrodite, for although the male reproductive element matures before the female, the testicles remain active later on, when female maturity has been achieved. Functionally, therefore, the flies are exclusively male in youth, and in later life are hermaphrodites in which femaleness is predominant. Owing to this difference in sexual activity as between the youthful form and the older form, a well-marked sexual dimorphism has arisen between the young and the old. Insects in the young masculine phase are long and slender, with a slim abdomen whose chitinous envelope is thin and delicate. As soon as ovarian activity begins, the insect increases notably in size, the abdomen becomes globular, and its chitinous investment thickens and stiffens.

Among fishes, too, there are some hermaphrodite species, for instance, the slime-fishes, myxinidæ, a family of the cyclostomata. Certain myxines lead a parasitic life attached to the body or in the abdominal cavity of other fishes, and we may presume that this parasitism has favoured the development of hermaphrodism. I have alluded to that probability before, without attempting an explanation. Let me do so now. We have learned from various examples that the distinction between the male sex and the female is interconnected with the body-chemistry, with metabolism; that a great abundance of nutriment and a vigorous process of tissue-change favours the development of the female sex, whereas when the food supply is scanty the body lacks energy to do more than achieve the further development of its masculine

rudiments. We learn, indeed, that when environing conditions change for the worse, the ovaries of females that are already fully developed may undergo atrophy, and that, out of the vestiges of these ovaries, the comparatively unexacting male reproductive organs may arise by a regenerative process. Parasites in general enjoy an excess of nutriment, which they derive from their hosts, and we may put forward the hypothesis that the surplus energy thence derived may enable them to bring to maturity not only the feminine reproductive rudiments but, in addition, the masculine. Still, the reader must not regard it as proved that copious nutriment and more favourable environing conditions in other respects are the determining causes in the origination of hermaphrodism.

Even among the bony fishes, those of the genus serranus are usually hermaphrodites, and Serranus scriba, the sea-perch, is invariably so. Surmounting the well-developed and elongated ovary is a large, arrow-shaped testicle. Self-fertilisation would appear to occur sometimes in these creatures ; at any rate, after depositing their ova, sea-perches have been observed to discharge a thick cloud of sperm over them. Still, it remains questionable whether the spermatozoa of an individual fish fertilise its own ova. In this respect nature has in some (by no means in all) cases devised means of preventing self-fertilisation. In one of the tunicates, the sea-squirt, Ciona intestinalis, it can be demonstrated that the ova of the hermaphrodite are immune to the attempts of its own spermatozoa to penetrate them, whereas the spermatozoa derived from other individuals regularly effect fertilisation.

Let us now return to the crustacea. The cirripeds are a sub-class containing numerous species, exclusively

pelagic. One of the best known is the barnacle, Lepas anatifera. Barnacles cling to stones, whales, turtles, etc., with the aid of the anterior antennæ situated at the front of the head, being permanently fixed through the secretion of a cement poured out from special glands at the root of the antenna—a cement which hardens very quickly. In these creatures, the part by which the attachment is effected is elongated into a pedicle or stalk, at the other end of which is the body of the animal, protected by calcified shell-plates, from between which the appendages, consisting usually of six pairs of thoracic feet, can be projected.

The German vernacular name of the creature is *Entenmuschel*, " duck-mussel " : " mussel " because the shape of the barnacle shell resembles that of a mussel ; and " duck " because medieval monks encouraged the absurd superstition that the barnacle or bernicle goose developed out of marine barnacles. On the ground that ducks and geese derive from fish (shell-fish), there could be no objection to eating them on fast-days ! Although Linnæus can have given no credence to the idea, it was he who gave the barnacle the Latin names of Lepas anserifera and (another species) Lepas anatifera, " goose-bearing ".

All the cirripeds have abandoned a free life, some of them clinging, as above described, to stones, whales, turtles, etc. ; others having become genuinely parasitic. For this reason many of them are hermaphrodite. It is true that the cirripeds are not pure hermaphrodites, for side by side with the hermaphrodite individuals there exist dwarf males, which were spoken of by Darwin as complemental males, and would seem to develop out of

the hermaphrodite form through atrophy of the feminine characteristics. Such, at any rate, was Darwin's view. Inasmuch as, however, dwarf males are found also in the species in which the sexes are differentiated, it is perhaps more reasonable to suppose that they are imperfectly developed members of a primarily male type, and that even among the hermaphrodite species such dwarf males have been retained to ensure cross-fertilisation among the hermaphrodites.

Certainly nature has taken other measures to provide against invariable self-fertilisation of the cirripeds, which usually live in large colonies upon a restricted area. The penis of these animals is extraordinarily long, so that it can usually traverse the distance which separates two neighbours. Often enough, however, the individual specimens are too far away from one another for mutual fertilisation to be possible, and then the dwarf males can play their part. Like all other cirripeds, the dwarf males are free-swimming only in the nauplius stage, becoming attached at or before sexual maturity to the body of a female or hermaphrodite member of the species, or in some cases penetrating the latter's body. Occasionally we may find a hundred or more dwarf males attached to one female. The organisation of this dwarf brood is often of an extremely degenerate character. In the most advanced instances of this, as in Alcippe lampas, the male consists of nothing more than a sac-shaped mantle enveloping the comparatively gigantic testicles, the seminal duct, and the long extrudible penis. The dwarf male may be said to have been degraded into something that is little more than a male reproductive organ.

Such organically degenerate " dwarf " males are found

among many species of animals, whereas, in the same species, the females attain a very large size.

We here see a striking parallelism between the final development of the male and the female reproductive cells and that of the male and female organisms bearing these cells. As far as the ovum is concerned, the principal aim is to equip it with the largest possible amount of nutritive material, even at the cost of number. In different animals this is attained in very different ways. Among many species the maternal organism develops special nutritive cells or other nutritive apparatus in its ovaries; in other instances there arise comprehensive glandular apparatus which provide the egg-cells with yolk and albumen, and often, for greater security, secrete a firm shell to protect the fertilised eggs. All these things are devised to safeguard the developing embryo. Frequently, indeed, as in the small primitive marine annelid Dinophilus apatris, we can observe how adjoining youthful ovum-forming cells will fuse, one of the two nuclei atrophying and disappearing, so that a single larger cell is constituted. This process is repeated several times, with the result that every ovum destined for maturation is composed of the plasma of a number of these primitive egg-cells. Subsequently the enlarged ova absorb fluid nutriment and grow to a considerable size. Not all the cells, however, enlarge to an equal extent, large and small ova existing side by side. Out of the large ova females proceed; out of the small ones, males. We shall, in due time, have to return to the consideration of Dinophilus.

As the ovum thus provides for the nutrition and the material development of the embryo, the spermatozoon

is relieved from this task. The latter's function is exclusively to transmit the paternal heredity factors which are incorporated in the chromatin of its nucleus, which has become the head of the spermatozoon. Since, especially in the case of those animals which discharge their reproductive products into the water, numberless spermatozoa perish without attaining their goal, it is essential to the preservation of the species that spermatozoa shall be formed in large numbers and shall be equipped with very active mobility. A man, for instance, discharges at each ejaculation round about two hundred million spermatozoa, only one of which will (if fertilisation takes place at all) encounter an ovum discharged from his partner's ovary and effect fertilisation. It has been calculated that in the course of a human male's life his testicles manufacture four to five hundred thousand milliards of spermatozoa, whereas the two female human ovaries will produce during a woman's lifetime only some three hundred ova that are ready for fertilisation, so that there are nearly two thousand milliards of spermatozoa at the disposal of each ovum.

The vast number of the spermatozoa and their extremely active mobility are, however, only achieved at the expense of their size and thanks to a regression of their cellular organisation, so that spermatozoa, regarded as cell-individuals, have lost almost the whole of their protoplasmic body. They produce, in compensation for this, new cell-organs : the vibratile tail-filament, a sort of beak on the front of the head to enable them to bore their way through the cell-wall of the ovum, and other accessory structures which facilitate speedy locomotion towards, search for, and penetration into, an ovum.

Among the bearers of the reproductive cells, the adult male and female animals, the respective sexes have corresponding tasks, the expression of a like division of labour. The female must produce the large egg-cells, equipped with an ample supply of yolk; must, in many species, provide space within her body for the development of the embryos; and must (in the case of the mammals) continue to nourish the young after birth with her own body-juices. In many instances, when the vital circumstances of the creature demand it, this leads to a great preponderance in the size of the female sex. The male, on the other hand, unless (as is not infrequent among the higher animals) he also helps in the upbringing of the brood, has as his only task to seek out the female, to couple with her, and to ejaculate his spermatozoon into her body. Such is his essential purpose in life. We can therefore understand why it sometimes comes to pass that, especially in species that have abandoned a free life, there are formed extremely elementary and quasi-degenerate dwarf males which are apt to be little more than masculine semen-preparing and copulatory organs. In many instances, however, these developmental trends overshoot their mark, leading, in extreme cases, to a great diminution and even to an elimination of the masculine type. Simultaneously, however, compensation takes place. The disappearance of the males is accompanied by an appearance of hermaphrodite forms; or the ova acquire the faculty of developing parthenogenetically, without fertilisation. This kind of reproduction, which will be considered more fully when we return to the discussion of the alternation of generations, mainly subserves the rapid multiplication and

diffusion of the species ; whereas, in such creatures, males appear only from time to time, after there have been several or a large number of parthenogenetic generations —the function of these occasional males being to provide for cross-fertilisation, for a regeneration of the stock, for amphimixis. In the case of many species of worms, this elimination of sex has gone even further. Not only have the males disappeared, but the female type has been suppressed, so that there exist only individuals which reproduce themselves exclusively by asexual means, by fission. Presumably these are species whose vital energy is declining, so that they are on the way towards extinction.

Although the rudiments of both the male and the female type are present in the developing ovum, it is as a rule decided in the moment of fertilisation which developmental trend will predominate, which assortment of these rudiments will gain the upper hand, whether ovaries together with the appropriate accessory organs and the secondary sexual characters of the female will be formed, or, on the other hand, testicles with the associated primary and secondary sexual characters of a male.

We have learned, however, that this decision achieved during fertilisation is not irrevocable ; that a change in environmental influences may subsequently switch the processes of growth over from the production of one sex to the other. There is a sort of warfare between the masculine and the feminine heredity qualities, a combat in which complete victory leads to the almost complete suppression of the rudiments of the antagonistic sex. It may, however, happen that the rudiments of both sexes develop in the growing individual, the proportion of femaleness or of maleness varying from case to case.

There then results the production of intermediate sexual conditions.

Every butterfly-collector is acquainted with the gypsy-moth, Lymantria dispar, diffused over Europe and Asia in numerous varieties. In lymantria a well-marked sexual dimorphism prevails. The male butterflies are smaller than the females, more slender, of a greyish-brown colour, with black markings on the upper side of the anterior wings, and their antennæ are equipped with a comb-like structure having broad teeth. The females are plump, and of a dirty white colour, with black bars across the anterior wings. Thus there is an obvious sexual differentiation. When males and females of the same variety are bred together, the offspring are always normal males and normal females. The results are very different, however, when the members of different varieties are crossed. As the outcome of such a hybridisation, we find that one sex of the offspring has normal sexual characters; but in the other sex, disturbances are manifest, with the result that it is really an intersex, the intersexuality being more or less marked according to the varieties that are interbred. In some instances, the disturbance of the natural balance of the sexes may go so far as to result in a complete transformation of one of the two sexes, so that the offspring consist exclusively of males or exclusively of females. If, for example, we cross a German female of the Schneidemühl variety with a Japanese male of the Gifu variety, the male offspring are normal males; but the female offspring, although they have certain female characteristics, have also in many respects a masculine type. This modification towards the opposite sex is much more marked when a

female of the Rhineland variety is hybridised with a male of the Japanese X variety. When a female of the Berlin variety is crossed with a male of the Aomori variety, a complete internal and external sexual transformation results in the female offspring, so that the result of the hybridisation is to produce males. Since normally, in this moth, the two sexes are produced in equal numbers, the outcome of the Berlin-Aomori hybridisation signifies that, while half of the offspring are insects primarily destined to have been males, the other half are females that have been transformed into males. The change does not affect the bodily qualities alone, for the instincts are likewise inverted. Whereas the female gypsy-moth is an inert creature, disinclined to use her wings, the male is active and continually in motion. Females that are intersexual, that have undergone only a moderate degree of change in the masculine direction, are quite as sluggish as normal females, and exert the ordinary sex appeal upon the males. But as the degree of masculinisation increases, the insects are seen to be more lively, and at the same time their attractiveness to the males diminishes. They seek out normal females, and try to copulate with them.

By certain other hybridisations, conversely, we can produce a male intersex, or can transform an originally masculine organism into a feminine one.

Here, in the last analysis, we must suppose that metabolic processes are once more responsible for the sexual metamorphosis. The nuclear chromatin is not only the conveyer of hereditary qualities, but also controls the tissue-change of the cells. We may assume that the spermatozoa introduce varying quantities of chromatin

into the ova during the act of fertilisation. An abundant supply of chromatin will intensify the process of tissue-change, and thus lead to the production of a female; whereas when the amount of chromatin introduced by the spermatozoon is smaller, the male rudiments in the ovum will achieve a preponderant development. One may suppose that, to begin with, when cross-fertilisation has been effected, the primary masculine or feminine developmental tendency is entered upon, and that, to keep to our first example, the rudiments of femininity begin to develop. Thereafter, however, the stronger, masculine factor comes into operation, and leads to the development of the male rudiments. The female characters that have already achieved some degree of development will continue to develop towards femininity, but all the other organs become masculinised, with the result that male and female qualities are produced in a motley mixture. The stronger the masculine factors introduced by the spermatozoon, the sooner will masculinity become dominant, counteracting the feminine trend that may originally have been present, and producing a more markedly male type. When the feminine tendency is very weak and the masculine tendency very strong (as happens when we cross a Berlin lymantria with an Aomori), the feminine rudiments may be inhibited, so that only the masculine rudiments prevail. The upshot is a complete sexual metamorphosis, and none but male butterflies are produced.

CHAPTER FOUR

AMATORY LIFE OF HERMAPHRODITE ANIMALS

MAN is an incomplete animal, or rather, individual men and women are incomplete creatures; they are but halves, and each of these halves is perpetually searching for its complement. This idea, which was first mooted by a philosopher in ancient Greece, is a beautiful image for the description of man's unappeasable love-yearning—unappeasable until the partner has been discovered with whom, in conjugal union, the separated halves can unite into a whole.

Hermaphrodite organisms are better off, or might be better off than we. From the first they have in their individual bodies the complementary masculine and feminine halves. The individuals need no partner. They are competent to gratify their own sexual impulse, masculine or feminine as the case may be; and out of self-" coupling ", out of an act of self-fertilisation, new generations can arise. But through self-fertilisation there are lost the decisive advantages of the separation of the sexes, thanks to which there occurs a union of the heredity factors of individuals differing in their bodily qualities, of individuals belonging to the same species but not closely akin. Nature will not readily allow the frustration of her purposes, the abandonment of something that has been gained in the slow course of evolution by

Dr. Georg Eberle

FIG. 11.—LOVE-PLAY IN THE EDIBLE SNAIL

Dr. Georg Eberle

FIG. 12.—SNAILS DURING THE EXTRUSION OF CUPID'S DART

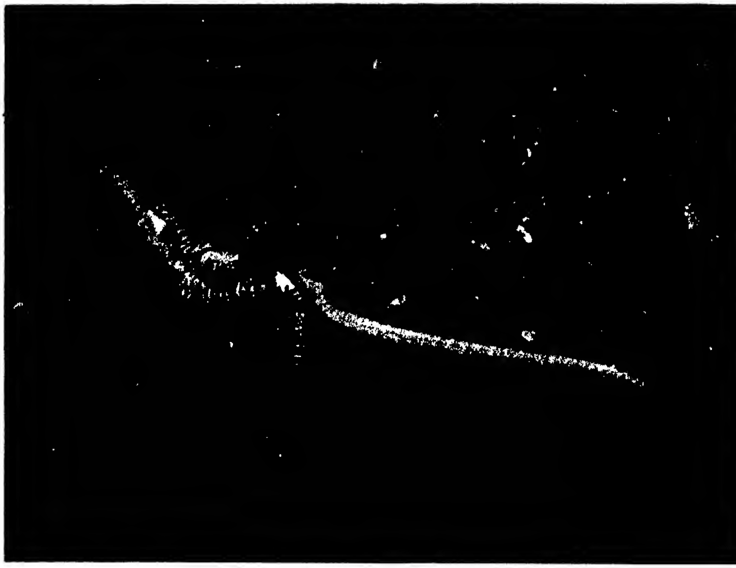
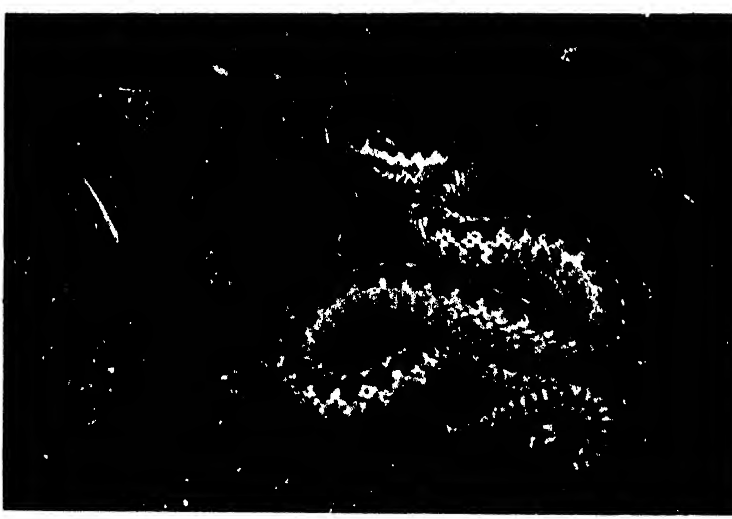


Fig. 13.—EARTHWORMS COPULATING



Karl Stülcken

Fig. 14.—LOVE-PLAY IN THE COMMON ADDER

selection, inheritance, and adaptation. There are, consequently, numerous expedients whereby self-fertilisation has been made difficult to or impossible for hermaphrodites, so that they are forced to copulate with other members of the species.

The simplest and most frequent way of preventing self-fertilisation is proterandria or proterogynia of the hermaphrodite, this meaning that in the hermaphrodite organism the male reproductive cells ripen before the female, or conversely. Most often, the spermatozoa ripen first, so that the hermaphrodite functions in youth exclusively as a male. Not until the testicles cease to exert their seminal function, shrink, and pass into a state of repose, do the ova ripen so that now the hermaphrodite becomes a female on heat. Even when ova and spermatozoa ripen simultaneously in a hermaphrodite, and when there is a bisexual reproductive gland (ovo-testis) with but a single duct from which the male and female reproductive products are evacuated, there will be found in the structure of the hermaphrodite, arrangements to hinder self-fertilisation so that this may only be practised as a last resort. All the same, there are various species of hermaphrodites in which, disadvantages notwithstanding, self-fertilisation is a general rule, and even the sole method of fertilisation. In the peculiar environing conditions of these creatures, self-fertilisation must obviously have become advantageous to the preservation of the species, as happens when such an animal has, in the course of its ancestral history, rarely been able to count upon finding a sexual partner at the appropriate time. In such instances, the instinct to self-fertilisation has become hereditarily fixed.

Organic evolution does not proceed in a uniformly ascending line, nor even in a continually ascending curve, for reversion often treads hard upon the heels of a higher evolution, or an advance in the development of certain organs and qualities may be accompanied by an involution or regression of others. Inasmuch as environing conditions are continually varying, although so slowly that the change is often imperceptible, particular organs which were admirably adapted for life under particular conditions may, when the conditions have been transformed, become superfluous or even injurious, and may consequently degenerate. The phylogeny of parasites shows this very clearly. Hidden away within the body of its host, the parasite has no need of locomotive organs, so they atrophy. It has no use for sense organs, so these likewise degenerate and disappear. The highly developed nervous system of the free-living congener is also needless for the parasite, and consequently decays. Bathed in the nutritive juices of the host, the parasite does not need a muscular system. Even the intestinal canal and the whole digestive apparatus may perish, when the surface of the body has taken over the function of absorbing nutriment. On the other hand, the reproductive glands are markedly developed, their activity remaining essential to the preservation and multiplication of the species. This is typical, for instance, of the females of some of the lower crabs, the copepods, which live parasitically as contrasted with the males of the same species which lead free lives. In these species, the bodies of the females have been so extensively modified and so much simplified, that nothing but the characteristic structure of the ovaries enables us to recognise them as copepods.

Self-copulation and self-fertilisation in hermaphrodites represent a reversion or degeneration of the sexual instinct as the outcome of adaptation to peculiar conditions of life. Speaking generally, hermaphrodites, not excepting those in which the male and female reproductive elements mature simultaneously, have a hereditary impulse to seek out another member of the species for an act of mutual copulation. Thus for hermaphrodite organisms there are three possible modes of sexual activity. There is self-fertilisation, which must be regarded as a last resort. Secondly, there is an act of reciprocal copulation in which both members of a hermaphrodite pair function simultaneously as males and as females. Thirdly and lastly, there is a unisexual copulation, in which the hermaphrodites, just like animals in which the sexes are distinct, function in coitus exclusively as males or exclusively as females, to change their rôle in a later act of intercourse.

As a typical instance of reciprocal fertilisation in a thoroughly hermaphrodite animal, let us consider the edible snail Helix pomatia. To understand this rather complicated process, it is necessary to be fairly well acquainted with the anatomical structure of the creature's reproductive organs. (See Fig. 15.)

In the edible snail almost the whole sexual apparatus is hermaphrodite. The principal organ is, of course, the reproductive gland, an unpaired ovo-testis, producing mature ova and mature spermatozoa side by side. This hermaphrodite gland is imbedded in the liver, in one of the uppermost coils of the helical shell. The products of the glands are excreted through a convoluted hermaphrodite duct, at the lower end of which there is a blind

diverticulum, known as the fertilisation-pouch. In this pouch, after the copulatory act has been completed, the snail's ova are fertilised by the spermatozoa of its partner. Close to the fertilisation-pouch, there opens into the hermaphrodite passage the duct of the great albumin-

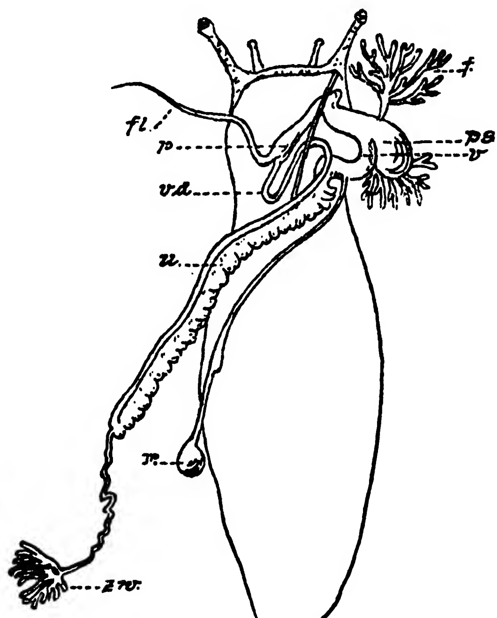


FIG. 15.—REPRODUCTIVE ORGANS OF THE EDIBLE SNAIL, DISSECTED OUT.

zw, hermaphrodite gland (ovo-testis) with hermaphrodite excretory duct. *u*, spermoviduct. *vd*, vas deferens. *p*, penis. *fl*, flagellum. *v*, vagina. *r*, receptaculum seminis. *ps*, pouch of Cupid's dart. *f*, digitate glands.

gland, the secretion of which surrounds the fertilised ova with an albuminoid nutritive envelope. Beyond this point, the hermaphrodite duct undergoes considerable enlargement to become the spermoviduct. The sperm-oviduct consists of the wide-lumened and tumefied oviduct or uterus, in whose walls there are numerous

glands, and the seminal duct which runs along one side of the uterus as a saccular groove. The respective lumens of the oviduct and of the seminal duct are still in open communication. Only at the lower end does the hermaphrodite tube split completely into two ducts, the vas deferens for the spermatozoa being now quite distinct from the oviduct. The oviduct leads into the female sexual passage, the vagina, which in its turn opens into the atrium, whose external aperture is situated beneath the right side of the head. Perched upon the back of the vagina is the stalked receptaculum seminis, which serves for the temporary storage of the partner's semen received during the act of conjugation. Close by the receptaculum seminis there open into the vagina the digitate glands, whose secretions serve to lubricate the vagina for the introduction of the penis. Below the digitate glands, finally, there open also into the vagina a large muscular pouch, the pouch of Cupid's dart. In its interior is the dart, a slender, stylet-shaped structure of carbonate of lime, which is used as a stimulus in the act of copulation, and assumes an important rôle in the preliminary love-play. (See Fig. 16.) During this love-play, amid convulsive twitchings the whole atrium is everted, so that the pouch of Cupid's dart is pressed against the surface of the partner's body. By forcible contractions of the muscular walls of the pouch, the dart is expelled at the moment of greatest sexual excitement. It penetrates the body of the sexual partner and breaks off in it like a glass dagger. Very soon, however, the glandular walls of the pouch of Cupid's dart will have secreted a new dart. Sometimes the piercing of the partner's body by Cupid's dart is mutual, but in the edible snail, as a rule, only one

of the copulating animals makes use of this stimulating organ.

It is now necessary to examine the male part of the reproductive apparatus more closely. The vas deferens is prolonged into the penile sac, which is capable of extrusion, but which, in the quiescent state, consists of poles that are intussuscepted or telescoped into one another. It opens into the atrium and when active is extruded

FIG. 16.—CUPID'S DART OF A SNAIL.
Shown below in cross-section.

through the conjoined sexual orifice. There is attached to the penis a retractor muscle, which serves to draw in the extruded penis when intercourse is over. There is also connected with the lumen of the penis a glandular appendage shaped like a whip-lash, the so-called flagellum, which secretes substances indispensable to the formation of the semen-capsules or spermatophores. For

the spermatozoa of the edible snail are not, like those of men and other vertebrates, evacuated as little caudate cells that swim freely in the seminal fluid, but are joined together in packets, like the cartridges of a magazine-rifle. Each of these packets, called a spermatophore, which has somewhat the shape of a pill, is delivered in mass during the act of intercourse. The extrusion and erection of the snail's penis are effected, like the erection of the human penis, by distension with blood, or, rather, hæmolymph, during the preliminary love-play. In proportion as the animal's sexual excitement increases, the distension becomes greater and greater, so that the penis becomes continually larger and harder. As in the case of man, there are special anatomical arrangements to hinder the efflux of the fluid contents of the organ. In the early stage of erection, the penis is a comparatively small and thin though semi-rigid tube, which can easily be introduced into the partner's sexual orifice ; but as soon as introduction has been effected, the blood pressure within it rises greatly, so that it becomes much enlarged, distends the partner's vagina, and is incarcerated there. When coitus is complete and sexual excitement subsides, the erectile mechanism quiets down, the hæmolymph which has been distending the penis flows back into the body-cavity of the snail, and the copulatory organ can be easily withdrawn by its retractor muscles.

Now let us consider the copulatory act in detail.

There are obvious changes in the behaviour of an edible snail when the sexual impulse becomes active. It crawls slowly hither and thither, halts for a time, starts again, halts once more, lifting its head high, and remains in this posture for a while before resuming its march.

As soon as two such rutting snails encounter one another, there begins an active love-play. The two bring the under-surface of their "feet" into close contact, and manifest great excitement. (Fig. 11, on plate facing p. 96.) But the animals are not yet ready for copulation. They detach themselves from one another, and rest separately, half contracted, for a time, while gathering their forces. This pause may last a quarter of an hour or longer. Then they get seriously to work. Drawing close together again and circling round one another in a peculiar way, they bring their sexual orifices (situated, as already said, upon the front of the right side of the body) into close apposition. These preliminaries may last an hour, or even two hours. Then there comes another pause for rest, after which the two snails evert their sexual orifices and press the soft, prolapsed portions closely together. At this moment of supreme excitement, one of the snails shoots its Cupid's dart into the body of its partner, which shrinks from the pain, but appears more excited than ever by the stimulus. Meanwhile the two penile sacs have been extruded, and each snail thrusts its virile member far into the other's vagina so that the clubbed end of the penis is apposed to the open orifice of the receptaculum seminis, into which a long gelatinous spermatophore is now expelled. (See Fig. 17.) In edible snails, the real copulatory act, which begins with the mutual introduction of the penes and ends with the discharge of the spermatophores, lasts no more than a few minutes, but there are other snails in which it may continue for more than an hour.

When the animals have fallen apart, they seem completely exhausted, and are apathetic. Their bodies are

shaken by convulsive undulatory movements, which probably serve to promote the passage of the spermatophores farther into the receptaculum seminis.

These snails do not find it altogether easy to hit upon the position requisite for mutual copulation, since the

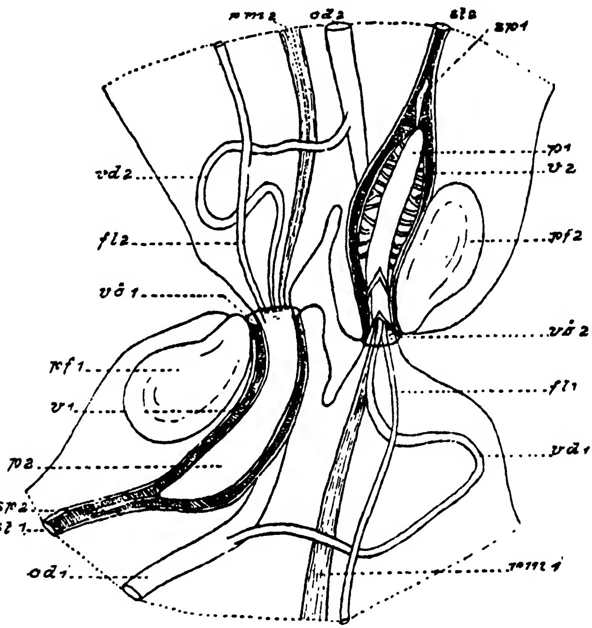


FIG. 17.—REPRODUCTIVE ORGANS OF TWO SNAILS SHOWN DIAGRAMMATICALLY WHEN THE ANIMALS ARE COPULATING. (*After* MEISENHEIMER.)

fl, flagellum. *od*, oviduct. *p*, penis. *pf*, pouch of Cupid's dart. *rm*, retractor muscle of penis. *sp*, spermatophore. *st*, peduncle of the receptaculum seminis. *v*, vagina. *vd*, vas deferens. *vo*, vaginal orifice.

two penile sacs must be brought precisely opposite the two vaginal orifices. As a rule, therefore, there are several ineffectual attempts before copulation can be achieved. Should only one of the partners succeed in penetrating, it does not take advantage of this in order to discharge its spermatophores, for the couple separate, and

try by renewed movements to get into a more favourable position. Meisenheimer, who has studied every detail of the love-play of edible snails, rightly insists that in these gasteropods " it is requisite for normal coitus that the active and the passive sexual need should be simultaneously satisfied in like manner ; and this statement seems generally applicable to all those hermaphrodite animals in which mutual copulation is the rule."

During their love-play, the snails are so greatly excited that they ignore anything else. The observer may lift them up and remove them to a new place, or may suddenly throw a strong light upon them, but heedless of these disturbances they continue to pursue their aim.

The introduction of the spermatophores into the peduncle of the receptaculum seminis is the end of copulation, but does not signify that fertilisation has been achieved. The spermatozoa have still to effect a long migration, back from the receptaculum seminis into the vagina, and thence along the oviduct into the fertilisation-pouch. Study of the slug named Arion empiricorum, has shown that in the receptaculum seminis the spermatozoa have to undergo a transformation to fit them for the act of fertilisation. The envelopes of the spermatophores burst, the spermatozoa are set free, and they discard their tail-filaments. It is in this modified form that they make their way through the vagina and the oviduct into the fertilisation-pouch and penetrate the ova awaiting them there. Herein we have another of nature's expedients for preventing as far as may be an act of self-fertilisation. If the spermatozoa were already fitted to effect fertilisation at the time when they leave the ovotestis, there would seem to be no reason why they should

not immediately fertilise the ova produced by the same gland—the ova with which they are in close contact in this hermaphrodite structure and in the hermaphrodite duct. Such self-fertilisation is not prevented by a natural immunity of the ova to the spermatozoa of the same individual, as happens in the case of ciona. When one of these snails has failed to find a partner for reciprocal fertilisation, it proceeds to effect self-fertilisation, but for this its spermatozoa must, just as if they were spermatozoa derived from another individual, undergo the necessary transformation in the receptaculum seminis and become tailless spermatozoa. For this, however, a long and complicated Odyssey is needed. First of all the spermatozoa pass from the hermaphrodite gland down the hermaphrodite duct into the spermoviduct, where they are packed into the spermatophores. Then such a spermatophore passes through the atrium and the vagina to the orifice of the receptaculum seminis, whence, by contraction of the muscular peduncle of that pouch, they are propelled into its interior. There the spermatophores burst, the spermatozoa are set free, and lose their tails—just as if they had been derived from another snail in an act of mutual intercourse. Now they have to make the same migration that would have been made by an extraneous spermatophore, and only when, after these manifold wanderings, the male reproductive elements have reached the fertilisation-pouch can they fertilise the ova derived from the same ovo-testis as themselves. Thus although self-fertilisation is possible, there are many difficulties in the way, and it is used only as a last resort, should reciprocal fertilisation fail to occur. In members of the genus limnæa, comprising various species of snails

found in our ponds and brooks, mutual copulation is general. Still, among them we often find individuals which appear to have renounced the search for a hermaphrodite partner, being content to introduce their long mobile penis into their own vagina, depositing spermatophores there.

Perhaps the most extraordinary form of love-activity is that of the great cellar-slug, Limax maximus, a creature found in damp woods, caves, and cellars. This snail is closely akin to the small grey field-slug, Limax agrestis, the enemy of all garden-lovers because of the damage it does to strawberries and vegetables, and which in damp years often appears in vast quantities.

Cellar-slugs, which vary in tint from ashen grey to black, attain a length of from four to five inches, and in southern Europe specimens as much as ten inches long have been seen. They love darkness, and their life—above all, their love-life—is passed in obscurity. They make love in the night-time.

At the rutting season they climb rocks or branches, and when two slugs ready for mating encounter one another in such a situation, a strange love-play begins. The cellar-slug has no Cupid's dart, but for the mutual excitation which is requisite to the extrusion of the virile member, reciprocal bodily stimulation is necessary. The slugs circle round one another, climb over one another, and lick one another with their odontophores—tongues each of which is armed with a sort of rasp, the radula. The use of this chitinous organ, here turned to account as a weapon of endearment, is so vigorous that the slugs sometimes inflict serious wounds upon one another. When a certain degree of excitement has been reached,

the animals, clinging by their hinder ends to the branch or to the rock, hang head downwards, looping round one another corkscrew fashion and endeavouring to bring their respective sexual orifices, which are situated on the right side of the body, into close contact. During this corkscrew embrace the two long and thick penile sacs—when erect, almost as long as the creatures themselves—are fully extruded.

By nature the penis is, obviously enough, designed for introduction into a female sexual orifice, to deposit there the sperm of the male to whom the penis belongs. But nature often pursues strange paths, and attains her ends in other ways than were originally planned. So it is with the cellar-slug. There is in their case no mutual penetration with the penes. Instead, the penile sacs of the copulating pair twine round one another corkscrew fashion like the slugs themselves. During this penile embrace the spermatophore in the lumen of each organ is expelled, the male A attaching its packet of sperm to the point of the penis of the male B, and conversely. It is obvious that in the criminal code of the limacidæ there can be no Paragraph 175. [Paragraph 175 in the German code deals with homosexual offences between males.] But there is worse to come!

When each slug has thus delivered its spermatophores to its partner, the pair separate from their embrace, each draws in its penis, and proceeds therewith to introduce the alien sperm into its own female genital receptacle. We see how right Ecclesiastes was when he said "there is no new thing under the sun". Millions upon millions of years before Döderlein practised the artificial insemination of women with semen introduced by a syringe, these

slugs had been doing the same thing. Though they had no syringes, they used their own penes to insert the alien sperm into the female parts of their hermaphrodite organs.

The copulatory process whereby fertilisation is effected in the ordinary earthworm is, if possible, even more complicated than this. Earthworms are likewise hermaphrodites, and engage in a reciprocal act of intercourse, each worm functioning simultaneously as male and female. For this purpose two worms place themselves side by side, tail to head and head to tail, with their abdomens in contact. Sexual congress lasts for a long time. (See Fig. 13, on second plate, facing p. 97.)

In the anterior third of an earthworm we observe a thickening more than an inch long, lighter in tint than the rest of the worm, known as the clitellum, which is much more richly furnished with glands than other parts of the organism. When the worms have got into apposition in the way above described, the clitellum pours out large amounts of a mucous secretion which by degrees forms a girdle round the two, and then hardens, contracting as it does so, with the result that the creatures are fastened together by a band which constricts their bodies. Now, from the male reproductive opening, which is in the fifteenth segment, the semen of the animals is poured out, the reproductive elements being contained in lenticular spermatophores. By movements resembling the peristaltic movements of the mammalian intestines, these spermatophores are carried along to the seminal pouches which open in the ninth and tenth segments, and the pouches of the two worms are packed full with one another's spermatophores. Then the worms separate,

and what next happens is most extraordinary. The semen is not, as might be expected, used by them for the fertilisation of their own ova. Instead of this, after a short time each of the two worms copulates with a new partner, whose ova are thus fertilised by the semen of another worm than the one with which it is now copulating, and which acts only as intermediary.

The variations of the sexual act are so numerous that I can only give a few especially characteristic examples. Superficially observed, the little amber-snail, Succinea putris, seems to behave exactly like the edible snail in the matter of reciprocal copulation. Yet the resemblance is only apparent, for the amber-snails are protandric. They are, indeed, hermaphrodite, but a young specimen which has matured as a male, and for the moment functions only as such, couples with an older specimen which has ceased to function as a male and has now matured as a female. As a reminiscence of her masculine youth, this female hermaphrodite does, indeed, introduce her penis into the vagina of her masculine hermaphrodite partner ; but since semen is no longer produced in her body her penis does not serve to transmit spermatozoa but only as a sexual stimulant and to lock the pair more closely in their mutual embrace. The only one of the two that is fertilised is the elder, which functions exclusively as a female.

Even when the male and the female reproductive cells ripen simultaneously, the sexual impulse may be of such a character that mature hermaphrodites, in whom ripe ova and ripe spermatozoa are simultaneously present, may function unisexually, only as males or only as females.

I have already recorded how the pond-snail, limnæa,

occasionally engages in self-fertilisation, but this practice is exceptional. In the pond-snail the male and female sexual apertures are distinct, the female orifice lying behind the male. When a limnæa is in the masculine mood, he seeks out another pond-snail which seems to him a suitable wife, crawls upon his mate's shell, extrudes his penis, and intromits the organ into the vagina of his chosen partner. Whereas in the reciprocal copulation of the edible snail both partners are in a state of extreme sexual excitement, the limnæa which functions as female seems to regard coitus with the utmost indifference. She makes no resistance, submits to the introduction of the virile member, but while the process is going on she crawls quietly about her business, and continues to feed as if nothing important were taking place. But now it may happen that a third pond-snail selects the male partner in this pairing as a wife for himself, crawls on the latter's back, and intromits his penis into " her " vagina. Other pond-snails may appear upon the scene and follow the example. Thus there may arise a whole chain of copulating animals, each link treating the anterior link as a female, and itself playing the female to the link behind—so that only the last male in the series functions exclusively as a male, and only the front snail functions exclusively as a female. Are we not entitled to speak of " natural perversions " ?

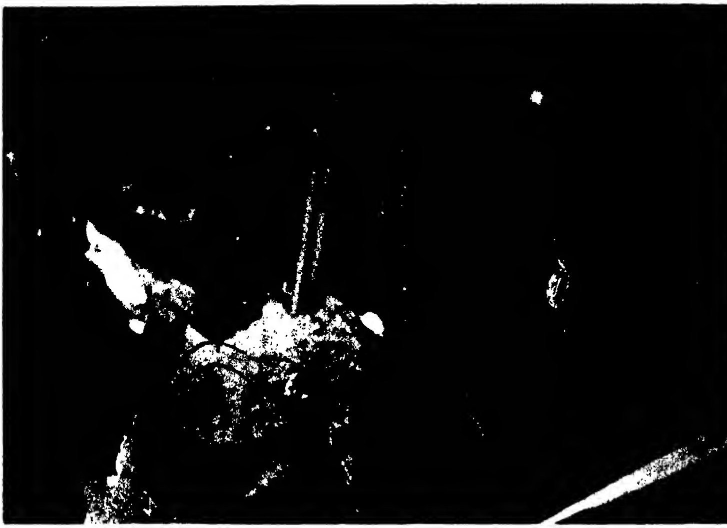
The case of limnæa does not stand alone. In the Bay of Kiel, there abounds upon the land covered with withering sea-grass the mollusc Acera bullata which forms such chains in which each member is functioning as a male in relation to the one in front and as a female in relation to the one behind. Its larger kinsman,

Paul Un

Fig. 18.—LOVE-PLAY OF MACROPODS

F. Schensky

Fig. 19.—DOGFISHES PAIRING



Karl Stülcken

FIG. 20.—GARDEN SPIDERS PAIRING

Karl Stülcken

FIG. 21.—HUNTING SPIDERS CARRYING THEIR YOUNG ON THEIR BACKS

Aplysia depilans, found in the Mediterranean, and sometimes spoken of as the sea-hare, behaves in like manner. (See Fig. 22.)

In concluding this chapter, I should like to say a few words more regarding self-copulation and self-fertilisation. Above all, self-copulation presupposes that the hermaphrodite masculine and feminine reproductive cells mature simultaneously, and that the sexual organs are so situated and constructed that the spermatozoa can be brought into contact with the ova. In order to effect this, the strangest bodily contortions sometimes occur. Consider, in this connection, the behaviour of the Medi-

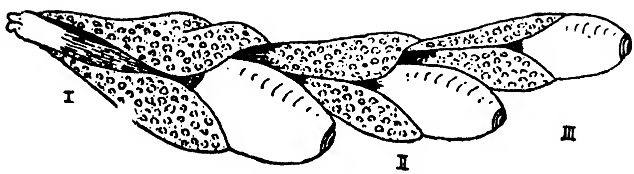


FIG. 22.—ACERA BULLATA COPULATING.

Three specimens are shown in a chain, of which the first link (I) functions only as a female, the second link (II) simultaneously as male and female, and the third link (III) exclusively as a male.

terranean planarian, Gunda segmentata, a little creature only a few millimetres in length. The animal's male and female reproductive organs are close together, the female organs being anterior to the male. Both open obliquely into a common atrium whose external orifice is upon the abdominal surface. To effect fertilisation, the spermatozoa must find their way into the receptaculum sêminis which debouches into the vagina. Technically it would seem almost impossible that the comparatively short penis could penetrate the animal's own vagina. But love laughs at locksmiths. If gunda wants to indulge in self-copulation, it bends its body sharply between the

two sexual orifices, so that the anterior part of its abdominal surface is in direct contact with the posterior part. Then the penis is so advantageously situated that, short though it be, it can discharge the male reproductive elements into the receptaculum.

Throughout the animal kingdom it is rarely found that the females are so indifferent to sexual relations as we humans are inclined to suppose, and sometimes they play an extremely active rôle. In the shark's intestine there lives a tape-worm, Anthobothrium musteli, in which self-fertilisation is the rule. The penis, situated close to the vaginal orifice, is a long, flaccid pouch without any capacity for erection, and it seems hard to understand how it can be introduced into the vagina. In actual fact, the male organ of the hermaphrodite would be ineffective unless the female organ came to its assistance. As soon as the extremity of the penis has been intromitted into the outer part of the vagina, an upward peristaltic movement sets in in the muscular wall of the latter, so that the penile sac is drawn far into the interior.

Enough has now been said regarding the amatory life of hermaphrodites. In succeeding chapters the reader will learn how sexuality has developed in the animals whose sexes are entirely distinct.

CHAPTER FIVE

AWAKENING OF THE SEXUAL IMPULSE

IF the reproductive cells either of separately sexed or of hermaphrodite animals are to fulfil their function of uniting for the production of new organisms, various conditions are indispensable. Above all, the male and female sexual products must ripen simultaneously. In addition the detumescent impulse (this meaning, as far as many of the lower organisms are concerned, nothing more than the impulse to discharge the reproductive cells) must arise simultaneously in both sexes ; and, finally, ova and spermatozoa must be brought into close proximity. Inasmuch as spermatozoa are equipped with a power of extremely vigorous independent motility, it is not essential that potential parents shall actively co-operate, for spermatozoa discharged into the water can swim for a considerable distance in search of an ovum. We have already learned that sexual lures discharged by the ovum —malic acid, for instance—guide the spermatozoa on their course. The existence of individuals in whom the sexes have become distinct, of separate males and separate females, does not therefore as yet mean that the bearers of the male and female reproductive glands must seek one another out and copulate. Copulation is a later evolutionary acquirement. Considered in the most elementary fashion, the respective members of the male and the female sex are but the foci, the fragments of nutritive

soil, in which male and female reproductive cells can originate. As independent individuals, sexed animals have, in the earlier stages of evolution, but little significance for the species. They eat and digest in order that the reproductive cells may be abundantly produced. The male and female individuals have fulfilled nature's task by producing and evacuating the reproductive products. Only at a later stage of organic development does the individual bearer of the sexual cells or the sexual glands acquire a degree of independence which endows it with more importance than that of a mere harbourer of germ- or sperm-cells. With the detumescent impulse there becomes more and more strongly associated the contrectative or caressive impulse. When this has developed, the animals are no longer content with the mere expulsion of their reproductive products, for there has awakened in them a sexual impulse, a desire to seek out a member of the opposite sex. They do not discharge their sexual products until they are in close proximity with the body of the sexual partner; and, in a still later stage of evolution, the male deposits his reproductive cells within the body of the female.

Just as the spermatozoon is much more active than the ovum and seeks the latter out, so with regard to the contrectative impulse which brings the two sexes into close contact. The male almost without exception plays the leading rôle.

The contrectative impulse can manifest itself in various forms and degrees, ranging from the mere approximation of male and female to a lively activity on the part of the male and sometimes on the part of the female as well.

This intensification of the sexual impulse, this increased

activity of the reproductive individual, is accompanied by profound changes in the body, leading to the growth of particular organs to facilitate the search for a mate: to the development of passive and active allurements and stimuli; to the appearance of locomotive organs and sense organs especially concerned with the sexual act, of clasping organs and copulatory organs—all these adapted to make the encounter of the male and female reproductive elements more certain. Inasmuch as the parts played by the respective sexes during and after coitus differ considerably, great differences between the male and female members of the species ensue. This differentiation may go so far, may lead males and females to diverge from one another so widely in aspect, may result in so far-reaching a sexual dimorphism, that no one who did not know the developmental history of the creatures concerned would suppose the males and females to belong to the same species. Various instances of such extreme sexual differentiation have been mentioned, so here, besides referring once more to the apple-moth, Biston pomonarius, I need allude only to the great frost-moth or fruit-moth, Hibernia defoliaria, in which, as in Biston pomonarius, the males are well-developed moths, but the females are inconspicuous wingless insects.

The simplest form of the contrectative impulse manifests itself as a tendency on the part of the male to seek out the female, or as a reciprocal attraction; culminating, when the members of the pair have come close together, in a simultaneous discharge of their respective sexual products, which are then left to themselves to find one another and achieve fertilisation. In this type of reproductive process, the mutual discovery of the sexual cells

must take place in a fluid or moist medium, wherein the spermatozoa can swim freely, so that it is met with in animals that inhabit water, or in those which seek the water at the period of sexual activity. Even when contrectation is as simple as this, it may already be promoted by sexual lures of various kinds. For instance, chemical excretions from the female, odours, and light-signals may play a part, attracting the males towards the females and arousing the detumescent impulse of the former.

When matters have gone as far as this, the next stage in the phylogenetic development of the contrectative or caressive impulse is that the members of the respective sexes, although they do not yet seek intimate bodily union, caress one another and thus mutually intensify the sexual excitement which leads them to evacuate their reproductive cells. A still further advance is made when the females, instead of discharging their mature but unfertilised ova, retain these in the interior of the body, where fertilisation takes place. Not even yet, however, is complete coitus necessary. The spermatozoa ejaculated by the male may find their own way into the sexual orifice of the female, or may be sucked in by the female genital organs.

The highest phase is reached when the male pours his seed directly into the female sexual orifice. This may be achieved by the mere pressing together of the two sexual orifices, as happens when the great night-slug, Arion, is pairing ; or elaborate external or extrudible male copulatory organs may develop, which can be thrust far into the bodies of the females, and thus bring the semen into close contact with the ova, as is seen to happen among edible snails, and as is the rule in birds and mammals. Natur-

ally, in such cases, the development of the male and the female reproductive organs must run a parallel or rather an inverse course, so that the female organ is, so to say, the negative of the male.

From the moment when the female no longer discharges her ova before they are fertilised, but retains them within her body during and after fertilisation, protects them within her own organism for a shorter or longer time, or even goes so far as to nourish the developing embryos with her own bodily juices, she has become a mother. This development into a mother does not merely induce important bodily changes, but leads in addition to the arising of a maternal instinct, of an impulse to protect the brood, which, in its higher forms, persists long after the birth of the offspring. When the male, too, becomes affected with this parental instinct and begins to take part in the care for and the upbringing of the young, the male reproductive animal has become a father. Thenceforward, out of this joint care for the young there at length ensue what we speak of as marriage and family life. The family community may be monogamous, polygamous, or collective. In the latter case, it leads to the formation of herds, or, in its highest forms to the origination of States. Once this phase has been reached, the development of States, of established societies, may, through the assignment of different functions to the various members of the community, lead to further differentiations, both bodily and mental, to a polymorphism within the species over and above ordinary sexual differentiation—a polymorphism we see in the social insects, such as bees, termites, and ants. The extreme known limit of such polymorphism in com-

munity-forming animals has been attained among the siphonophora, a sub-class of the hydrozoa, in which the State has once more become a unified organism, of which the citizens have been reduced to the level of mere organs of the State as individual.

Thus whereas in the lowest grade of sexual development, the two reproductive individuals have played their main part in life after producing and discharging the reproductive cells, and frequently perish very soon or even immediately after the evacuation of these, having become superfluous to the preservation of the species—an enlargement of the functions of the parental organism, and the prolongation of the period in which the young are tended and trained, lead to a more and more diversified bodily and mental individual development, to a more marked dependence of the young upon the male and female carriers of the reproductive cells, and simultaneously to a considerable prolongation of the life of the sexual individuals. Death, which came into the world with the appearance of the metazoa, with the distinction between somatic and reproductive cells, between sexual individuals and sexual cells, is once more postponed.

I do not wish to imply that sexual evolution has universally and in all its details followed the course above described ; but every one of the phases mentioned has been passed through in the phylogeny of every species, no matter in what order the phases have succeeded one another ; and even in the extant animal world we find among the different classes of animals instances of every kind. Some of these we must now consider.

With the recurrence of spring, the trees and lesser plants put forth leaves, bear buds, and open their flowers,

and at the same time butterflies and other insects appear upon the scene. Almost on the same day of the month, year after year, the swallows and the swifts return to northern Europe from their winter quarters in warmer climes and begin to build their nests or reoccupy the old ones. Every year, at the close of September, the forests resound with the belling of sexually excited stags. A severe winter may doubtless delay the spring's awakening; but even when April nights are cold, the buds begin to show upon trees and bushes, and the orchards brighten with white and pink and red flowers. Often enough this faithfulness to the calendar has to be paid for by the nipping of the buds and blossoms with frost. Every twenty-eight days, and in many women at the same hour of the day, menstruation recurs. Year after year in October and November, each month on the day before the last quarter of the moon, there appear at dawn upon the coasts of Samoa and the Fiji Islands vast quantities of palolo worms, to complete a sexual round which will presently be described. All these regular occurrences are manifestations of the law of periodicity which dominates the whole of organic and inorganic nature. Life proceeds in accordance with a definite rhythm, and its main cycles are subdivided into lesser cycles. We can perceive this in ourselves. Without discernible reason, we pass through periods of depression and euphoria, and this appearance and disappearance of cheerful and sad moods "keeps time" so remarkably well that Wilhelm Fliess has good reason for declaring the figures eight-and-twenty and three-and-twenty to be masculine and feminine, mingling bisexually in every human being, and finding expression in one way or another. Not in

woman alone, but in man as well, there is a sexual rhythm, excitement and potency recurring at regular intervals, this time-keeping being connected with the "ebb and flow of the sexual hormones", although the unnaturalness of civilised life has done a good deal to throw a veil round such relationships. In widely severed parts of the world, the native races, standing at a lower level of civilisation than ourselves, engage in spring and autumn festivals, characterised by orgiastic excesses and by a marked increase in the number of births nine months later. There is no chance concomitance here, for the festivals in question are expressions of a periodical increase in sexual excitability. The moon, too, makes its influence manifest in these matters.

The ripening and the discharge of the reproductive products is subject to the same periodicity, a knowledge of which is of great biological importance in the discovery of ova and spermatozoa. An additional important factor for ensuring fertilisation in those animals which, although they have distinctive sexes, have not yet developed a contrectative impulse, so that the males are not yet impelled to seek out the females, is the close spatial juxtaposition of those animals which do not live free lives, such as sea-anemones, corals, sea-squirts, barnacles, tubulariæ, etc.; or, in the case of free-living animals, a tendency to remain close together in large herds. Frequently, in aquatic animals, the main trend towards approximation is promoted by currents or by winds. Such a "social impulse" as this, which keeps the members of the species together, has nothing mystical about it, but is of a self-evident character. If, for instance, a number of individuals of a species find them-

selves in the best, the most favourable conditions life can offer them, they multiply abundantly, and nothing will induce them voluntarily to leave that place. As long as the conditions of life remain favourable, there will be a great many members of the species upon a confined area—their population will be thick upon the ground.

Sea-urchins and other echinodermata are, as a rule, closely aggregated. Subject to the law of periodicity, the males and females simultaneously discharge spermatozoa and ova into the water, and there the spermatozoa, allured by chemical stimuli, on their own account seek out the ova. When approached by a spermatozoon, the ovum, as already described, thrusts forth a little protoplasmic process, the receptive eminence, into which the spermatozoon pushes its head. The tail of the male reproductive cell is left outside, but the head, which represents the male pronucleus, unites with the female pronucleus, so that the maternal and paternal heredity factors are fused in the fertilised ovum for the formation of a new individual. (See Fig. 7.) Immediately after the head of the spermatozoon has penetrated the ovum, the outer layer of the latter's protoplasm becomes condensed to form what is termed the vitelline membrane, which serves as an obstacle to the entrance of any more spermatozoa, and thus prevents duplex or multiple fertilisation.

Even in this primitive method of sexual reproduction, we already note instances where there is a certain amount of mutual influence exerted by the sexes, an influence which may be regarded as the beginning of a contrectative impulse.

Among the molluscs belonging to the order placophora

(a very ancient order stretching back into palæozoic times), whose numerous species live by preference on the seashore in the tidal zone, where they are attached by suckers to rocks and stones, there is a rigid separation between the sexes. They, like the echinodermata, simply discharge their reproductive products into the surrounding water, the males setting the example, which is ere long followed by the females. It seems perfectly clear that from the masses of sperm thus evacuated into the water there must be poured forth chemical stimuli which act upon the females and induce them in their turn to discharge their ova. At any rate, we find that male scarabee-snails, when kept in an aquarium in which there are no females, continue to discharge their reproductive cells at regular times, whereas the females of the same species, when kept under like conditions but separated from their male partners, retain their sexual products.

Of course countless numbers of the reproductive cells thus set free perish without achieving a union. Millions, nay milliards, of spermatozoa never hit the target; but by the mass production of spermatozoa nature has ensured that, notwithstanding this wastage, a sufficient number of ova shall be fertilised to ensure the perpetuation of the species. In the echinodermata, for instance, the male reproductive glands are almost as large as the ovaries. When we remember that the ovum of a sea-urchin is about two hundred thousand times as large as a spermatozoon, we can form some sort of idea of what vast numbers of spermatozoa must be generated in these huge testicles.

In many parts of Germany there abounds in vast numbers a small blackish fly with brownish-yellow legs, technically known as Ciara militaris. Out of its ova there

develop glassy-white larvæ, about one centimetre long, with shiny black heads. The larvæ inhabit the woods, where they are hid beneath rotting leaves, so that they readily escape notice. At times, however, without any obvious reason, these larvæ show a new kind of behaviour. Thousands upon thousands of them creep out of their hiding-places and form in file, so that the column may sometimes be several yards long. The army makes its way slowly forward, looking like a thin, white, repulsive snake. In such a close formation, the creatures will often cover considerable distances, and reform their Indian file promptly whenever a foot or a carriage-wheel has disturbed the order of march. The appearance of these " army-worms " often gave rise to superstitions in earlier days, when they were supposed to herald war, failure of the crops, or pestilence. We do not know the nature of the force which constrains the creatures to their joint migration. It cannot be a sexual impulse, for the larvæ are not yet sexually mature and will not become so until they have reached the imago stage. Adult insects of other species, such as dragon-flies, grasshoppers, and butterflies, often flock together in millions, to fly in close proximity over considerable distances. Especially is this characteristic of locusts. Here, however, hunger is certainly the motive force, and not the sexual impulse.

Such migrations, determined by causes which remain inexplicable, may subserve the purposes of reproduction even though a sexual impulse is lacking. We see this, for instance, in the polychæte chætopod, Eunice viridis, whence is derived the palolo worm to which allusion was made a few pages back. (See Fig. 23.) In many of the polychæte chætopods, as for instance in

Nereis cultrifera which is common in the Mediterranean, the creature's life is divided into two sharply distinguished periods. They begin their existence in a condition of sexual immaturity as long, slender worms of uniform diameter, whose segments are furnished with small foot-stumps, beset with short bristles. These foot-stumps, known as parapodia, serve the worm for locomotion as it crawls hither and thither along the sea-bottom. When

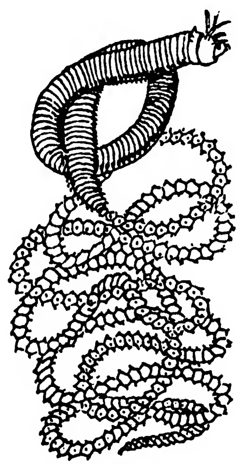


FIG. 23.—PALOLO WORM, EUNICE VIRIDIS.

When sexual maturity is attained, the thin posterior portion (which is but a string of pseudo-segments laden with reproductive cells) breaks away from the thick anterior portion which has the customary aspect of a segmented worm.

the sea-centipede passes from this primary asexual phase into the secondary phase of sexual maturity, the front sixteen to twenty segments of the body remain unchanged, but on the posterior segments, those which bear the reproductive products, there grow upon the parapodia long and wide oar-shaped bristles, differing somewhat in form in the two sexes, and enabling the worms, which hitherto have been confined to the sea-floor, to swim

freely through the water, whereby the mutual approximation of the sexes is greatly facilitated.

In like manner the palolo worm develops such a male or female posterior sexual portion, which is distended with reproductive products. Eunice lives hidden away in clefts among the coral reefs. Its body, like that of nereis, is composed of a great number of segments. The anterior segments, which have no connection with the sexual life, are comparatively thick. They form the body, properly speaking, of the worm, and contain all its important organs except those of reproduction. Contrasting strongly with the anterior portion is the posterior, which consists of long and narrow segments. At the period of sexual maturity, this " abdomen ", which is nearly a yard long, becomes filled almost to bursting with reproductive cells, severs itself from the anterior part of the body, and, now representing the real palolo, rises to the surface of the sea. Larger and continually larger numbers swim up out of the rifts in the coral, combine into huge armies, and start on their migration. As we have already learned, this severance of the palolo portion occurs twice every year, in October and November, the day before the last quarter of the moon. The second swarm is even mightier than the first, being spoken of by the natives as " mblalolo lailai ", the great palolo season, in contrast with the " mblalolo levu ", the small palolo season. The arrival of these troops of worms is a time of high festival for the islanders. The precursors of the swarm appear before dawn, and as soon as the sun shows itself over the horizon larger and larger numbers flock towards the shore. As far as eye can see, the ocean is filled with them, so that it " looks as if it had become

solidified ". So closely pressed together are the bodies of the creatures, that an oar stuck into the sea among them will stand upright for a considerable time, as if in thick treacle. At daybreak young and old among the indigenes come down to the shore with baskets and nets, ready to reap the harvest of the ocean, men, women and children plunging into the water directly the swarm arrives. The Fijians and the Samoans regard the palolo as a peculiar delicacy, eating it both raw and roasted. Nor is the animal distasteful to European palates.

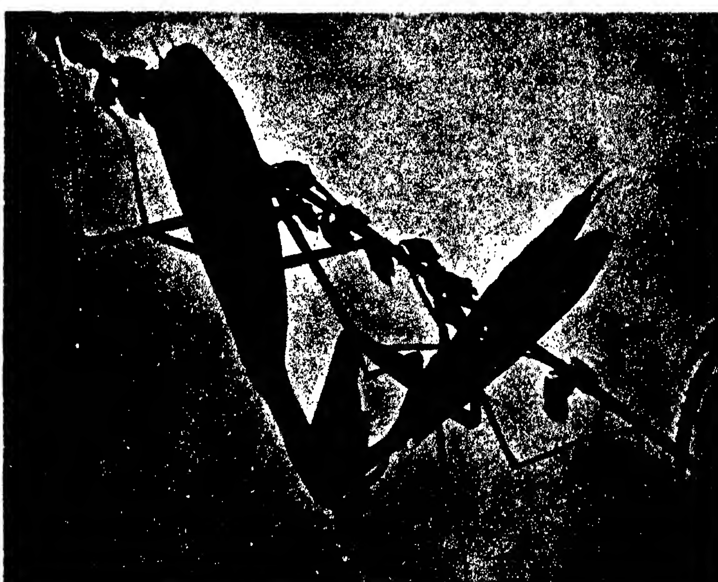
The segments of this sexually ripe palolo readily fall asunder and burst, pouring their ova and spermatozoa into the water in such quantities that the sea becomes milky. Thus, without the working of a sexual impulse, fertilisation is provided for through this mysterious periodical migratory impulse, which does not even affect the whole animal, but only a part of its body.

A variant is offered by the sexual reproduction of the little fresh-water polyps, Hydra viridis and Hydra fusca, in so far as fertilisation takes place in the maternal body. As previously explained, these creatures reproduce themselves mainly by partition or budding, without any intervention of sex ; and, since Hydra is only capable of a very small amount of locomotion, we can readily understand that the offspring of such a sexual reproduction remain confined to a comparatively small space.

From time to time, however, asexual reproduction gives place to sexual. In the body-wall of the polyp certain cells begin to proliferate actively, and as a result of this there may be formed both male and female reproductive glands on the same animal, or there may be an assignment of the male and female gonads to different

C. O. Bartels

FIG. 24.—PRAYING MANTISES, A COPULATING PAIR



C. O. Bartels

FIG. 25.—IDEM, SHOWING THE FATE OF THE MALE AFTER COPULATION

individuals, so that a sexual differentiation has occurred. Hydra has no excretory duct for the reproductive products. The teat-shaped testicle becomes more and more distended, until at length it bursts and the masses of semen are discharged into the water. The spermatozoa, freely swimming, seek out another hydra, all endeavouring to enter the large ovum that is embedded in the body-wall of the polyp, and the spermatozoon that wins the race effects fertilisation. In hydra there is no care for the embryos. Shortly after fertilisation, the ovary, too, bursts, and the fertilised ovum is evacuated into the water. Although fertilisation takes place in the maternal body, there is no active participation in reproduction by the separate sexual individuals.

At a higher stage of sexual organisation which has been achieved by the marine kindred of these fresh-water polyps, namely the scyphozoa, of which we shall have to speak again later, the reproductive glands have their seat in the interior of the body, in the intestino-somatic cavity, the so-called gastro-vascular space. Here, likewise, the discharge of the reproductive products still takes place through bursting of the reproductive glands, so that the ova and the spermatozoa are set free in the intestino-somatic cavity, and are then discharged through the mouth into the sea-water, where fertilisation takes place. Similar conditions obtain among the "coral-insects" or antozoa (in which the sexes are generally distinct), among the sea-roses, and among the rod-forming corals. In them, also, the envelope of the reproductive glands bursts when the sexual products ripen. Here, however, fertilisation takes place within the stomach of the maternal animal, in whose interior the embryo

develops into a planula larva or even into a young tentacle-bearing polyp, which only thereafter leaves the protection of the maternal organism.

When the reproductive glands are still more deeply situated in the body of the parent without any provision having yet occurred for the discharge of ova and spermatozoa, the evacuation of the ripe sexual product often takes place through such severe lacerations that the parent animal succumbs. We can watch this in many worms, but also in animals standing much higher in the organic scale, as for instance in the tailed tunicates or appendicularia, which are regarded as proto-vertebrates. In these latter organisms, however, such primitive conditions are probably the upshot of a reversion.

The evolution of the sexual impulse out of a purely evacuative impulse does not necessarily march with the phylogenetic course. In many animals whose kindred are still nothing more than producing machines and evacuating machines for the developing and mature reproductive cells, we can already see the beginnings of a contrectative impulse. The reader will remember that most of the echinodermata, when the time of sexual maturity arrives, simply discharge their reproductive cells into the water, without any attempt on the part of males or females to approach one another, or to trouble themselves about one another at all. In one of the star-fishes, however, Asterina gibbosa, it is different. Several male asterinæ throng round an oviparous female, embrace her with their rays, and in this position eject their sperm over the ova that are in course of ejaculation. Nay, already in many of the echinodermata there has already developed a system for the care of the embryos, the mother growing peculiar

organs for this purpose, so that the two sexes are obviously distinct.

The development of the contrectative impulse can be traced most characteristically by a study of fishes.

Everyone is familiar with or has at any rate heard of the huge shoals of herring, whereby the sea is filled for miles with a gleaming mass of silvery bodies. So thick may the shoal be that a rowing-boat can scarcely make its way through the waters; and, indeed, many trustworthy observers declare that a small boat can actually be lifted almost out of the sea by the press of fish. In this case, presumably, too, it is not a sexual impulse which brings the herring together, for these creatures live in shoals throughout the year—shoals varying in size according to the age and the size of the fish. Probably a herring-shoal is simply on the hunt for food. Herring live chiefly upon tiny crustacea, which in their turn are nourished upon dwarf plankton, which mainly consists of microscopically small vegetable organisms. This dwarf plankton is carried by sea-currents in particular directions, with the result that wherever it abounds the crustacea are found in vast numbers, and, in turn, the herring assemble in huge shoals. Furthermore, as the sheep-dog drives the sheep together, so are the herring forced into an evermore compact shoal by the attacks of their numerous enemies from the depths, from the sides, and from the air. Thus the herring-shoals mainly follow the marine currents, their course varying with the secular changes in these.

Packed together as above described, at the spawning season the fish usually seek the coast or the brackish water of bays and estuaries, and there, under the influence of their periodically ensuing detumescent impulse, discharge

their sexual products in such gigantic quantities that the sea-water is clouded for miles by ova and spermatozoa. Since the female herrings in the shoal swim near the surface, and the males below them, the ova, sinking through the water, pass through a zone where spermatozoa abound and can readily be fertilised. Indeed, it is scarcely possible for the ova to escape fertilisation.

A female herring produces about thirty thousand eggs, and from this the enormous rate of reproduction may be imagined, even though only a fraction of the fertilised ova succeed in passing through all the phases of growth to become sexually mature fish. This colossal fertility is necessary for the preservation of the species, in view of the countless foes which attack herrings in the water and from the air—to say nothing of the devastation worked among them by human beings. Yet a herring is far from being one of the most fertile among the fishes. A carp produces five hundred thousand ova ; a sturgeon, which is kind enough to supply us with caviar, five million ; an eel, about six million ; and a cod, from nine to ten million. If we were to suppose that all the ova of a sturgeon developed into sexually mature individuals, half of them males and half of them females, and that this rate of reproduction were to continue for no more than four generations, the offspring of the fourth generation would produce an amount of caviar which, compressed into a sphere, would be larger than our globe. Unfortunately, the increase of these useful creatures is seriously restricted by the struggle for existence.

Yet with the foregoing figures we have by no means reached the limit of fertility in the animal kingdom. A queen termite, for instance, a female which has become

transformed into a mere egg-laying machine, lays about eighty thousand eggs a day, which would amount to over eight-and-twenty millions a year. Since these eggs hatch out and the insects grow to maturity in the secure protection of the termite's nest and are sedulously cared for, the casuality list is naturally small ; but in return for this the queen, who is the only effective female of the whole tribe, is alone responsible for the preservation of the species. [In case of accident, however, there are nymphs ready to take the queen's place when their reproductive organs have been suitably stimulated by a special diet.] The migration of certain other fishes than herring is wholly controlled by the contrectative impulse. This impulse has in them become so powerful that throughout the period of migration, which lasts for many weeks, the animals cease to feed.

The most striking examples of such migratory impulses determined by the ripening of the reproductive cells are afforded by the ascent of salmon from the seas up the rivers far into the mountains and the inverse wandering of eels down the rivers into the abysses of the sea.

The " running-up " of the salmon displays the periodicity which is general throughout organic life. Almost exactly year after year on July 25, St. James's Day, there appear in the mouths of the Rhine, swimming upstream from the sea, the salmon which the Germans (from this date) call " Jakobslachse ". These are young salmon in their third year, exclusively males. In the end of July and the beginning of August, the Jakobslachs is followed by the Sommerlachs, a four-year-old female, for the first time sexually mature. In November begins the migration of the great Winterlachs, which may be as

much as a yard long. This migration proceeds throughout the winter and continues until March. The upstream movement is fairly slow. Not until the end of September or October do the Jakobslachse and Sommerlachse reach their spawning-place among the mountains in the upper courses of the Rhine, and the Winterlachse arrive, of course, much later. During their migration, the animals have no time to spare for eating. Their intestines shrink, their muscular and fatty tissues are largely consumed, while simultaneously the reproductive cells mature at the cost of the body-substance. The salmon allow nothing to hinder them in this " run-up " to the nuptial region. Waterfalls, rapids, and weirs are surmounted by swimming or by leaps. In the pool below a waterfall, the salmon will bend itself like a drawn bow, so that its caudal fin is almost in contact with its head. Then, with a sudden relaxation of tension, it leaps out of the water and springs through the air to surmount the cataract. Leaps of more than fifteen feet high and nearly twenty feet long have been watched by trustworthy observers. If the first attempt fails, the salmon will try a second and a third time until it achieves its goal. During these leaps, many of the salmon engaged in the run-up strike the rocks and are fatally wounded. But the uninjured preponderate in number and continue their way upstream. They traverse the lakes into which, from time to time, the rivers expand, until they reach the upper waters among the mountains, three thousand feet or more above sea-level. It is at this altitude that they pair. Many of the Rhine salmon diverge from the main stream up the Aar and the Limmat, swim the length of Lake Zurich, continue their way up the Linth and across

the Wallensee, penetrating into the Seetz, and ever higher and higher. In like manner they swim into the other tributaries of the Rhine. Meanwhile their reproductive glands have greatly enlarged, so that in the female salmon these glands have increased from 0·3 per cent to from 20 to 25 per cent of the body-weight. The testicles of the male have undergone a corresponding development. Outwardly, moreover, there is a striking change in the male, which plainly indicates that the contrectative impulse has begun to stir in them. They put on a handsome wedding garment. The belly, especially in the older males, becomes purplish red in colour, while upon the head a red zigzag line stands out clearly upon the general ground of blue. These bright tints invade the fins as well, which simultaneously grow thicker.

When the end of the long journey has been reached, the female, who usually has as companions one fully adult male and several young males, chooses a shallow pool with a sandy or gravelly floor. With her tail, she scoops out a shallow pit or trough known as the " redd ". Meanwhile, the full-grown male keeps jealous watch that no rival shall draw near, and the young males, greatly excited, swim round and round the breeding-place. Should a rival adult venture to invade the precincts, the chosen male attacks him fiercely, and a fight ensues which often has a fatal issue. When the pit for the reception of the ova is ready, the female rubs herself along the bottom from one side of it to the other, while discharging some of her ova. Thereupon the male enters the pit and discharges his semen, and then all the ova are covered with a thin layer of sand by a fanning movement of the caudal fins. The attendant youthful males watch

the proceedings eagerly, manifestly hoping that they, too, will be given an opportunity for the satisfaction of their detumescent and contrectative impulses. This usually happens. Should the elder male have his attention distracted by the approach of a rival, the female does not cease from her spawning activities, continuing every few minutes to discharge fresh ova. Here is the young males' chance. They seize their opportunity, pressing into the pit and discharging their semen, just as among stags, when the elder bucks are fighting savagely, the one-year-olds mount the does. Still, these youngsters are but a temporary resource. Should the old " milter " be netted while the spawning is in progress, the female soon ceases to discharge her ova, sets out in search of a new partner, and returns with another full-grown male. Young describes a female salmon alluring nine fresh males in succession to the spawning-place, and, when the last adult male had been netted, the female went off again upon the search. Since (obviously) she was unable to find yet another full-grown male salmon, she returned in the company of a large male trout. The long migration upstream and the excitement of spawning induce such complete exhaustion in the salmon that they become almost powerless. Making scarcely a movement, they allow themselves to drift downstream to lower altitudes, where they gradually recover their strength. When the spring freshet comes, they slowly swim back to the sea. It would seem that during their return seaward, just as during the run-up, the salmon take no food. In the ocean it is probable that these fish remain not far from the river-mouth, for the marking of fish has shown that they regularly return to the same breeding-ground: the

Rhine salmon come back to the Rhine ; the Elbe salmon, to the Elbe ; the Weser salmon, to the Weser.

The fertilised ova take from thirty to one hundred and sixty days to hatch, according to temperature. The larva or " alevin " which hatches from the egg is a tiny creature with a large umbilical sac attached to the breast behind the gill openings. This food reserve lasts from four to eight weeks, when the young fish becomes a " parr ". These young salmon spend two summers in their fresh-water birthplace, and then, in the second autumn, make their way down to the sea, to return in due course to their birthplace as St. James's salmon or Sommerlachse. In England the immature salmon on its first return to the river is called a grilse. [It is not true of all salmon that they never feed in fresh water, though they certainly feed very little there once they have passed the " smolt " stage in which they acquire their silvery scales. Their digestive tract is in a functionless and almost atrophic condition during the run-up and the drift down ; but there would be no sport of fly-fishing if they never fed in the rivers. Probably the British and Irish salmon are more inclined than continental salmon to rise to a fly ; and salmon can also be caught by spinning with an artificial minnow or with some small natural fish. A boiled prawn is likewise a deadly bait. The quinnat, or Californian salmon, seems never to rise at a fly.]

Very interesting is the migration of the huck or huchen, Salmo hucho, an enormous trout living in the Danube. In the early spring the huck begin to migrate into the tributaries of the great river, and to run up as far as the mountain torrents of Upper Bavaria. One would have

thought that the weirs which have been constructed in these streams would prove insuperable, but the great fish, which may weigh as much as a hundredweight, manage to leap the obstacles.

The lamprey, which everyone knows (at any rate as a canned delicacy), is also driven by its sexual impulse to ascend the rivers, although it does not make its way to the high mountains as do salmon and huck. Many lampreys get a lift on these wanderings by clinging with their sucker-like mouths to salmon engaged in the run-up, being thus helped through the rapids and over the weirs. But in the absence of such aid, they can make shift to mount even perpendicular waterfalls.

In contrast with the salmon and the huck, the eel is driven by its sexual impulse downwards from the streams into the sea. The life-history of the eel was for a long time veiled in obscurity. Even the largest and oldest eels, ranging up to a yard in length, that were found in rivers and lakes had reproductive organs in an embryonic state. It was, indeed, supposed that eels descended to the sea for part of their life, but no one knew their breeding-places or what very young eels looked like.

In the 'fifties of the last century, Kaup caught in the North Sea specimens of a small, laterally flattened transparent little fish, and gave it the name of Leptocephalus brevirostris. However, at this time no one dreamed that leptocephalus was the larval or youthful form of the ordinary river eel.

In the end of January there appear at the mouths of the rivers debouching on the Atlantic coasts of France and Britain, tiny translucent fish, thin as fine string, being no more than one-twentieth to one-twelfth of an

inch thick and about three inches long. These are young eels. In the German vernacular, owing to their transparency, they are spoken of as " glass-eels ". The gastro-intestinal canal of these glass-eels is still empty, and it would seem that they can as yet have taken no nutriment, having grown to their present size with the exclusive aid of nutritive material derived from the mother. On the coast of the English Channel and farther east, these young eels do not appear until later in the year: at the mouths of the Rhine, in February and March; at the mouth of the Elbe, in April and May; while their appearance in the Oder and the Vistula comes even later. At this time their aspect has already changed, for they have darkened in tint through the deposit of pigment in the skin, and their stomachs and intestinal canals are full of food in course of digestion. Since the young eels make their appearance sooner, the nearer the mouths of the rivers lie to the Atlantic Ocean, it is plain that they must have come from that ocean, and that it is an eastward migration which brings them into the rivers where they pass their subsequent youth.

The migration of the young eels is effected in a strange marching order. By milliards they swim upstream, close to the bank, in columns from ten to fifteen inches wide, and miles long. Every curve of the bank is meticulously followed. Like lampreys, the eels overcome all obstacles, utilising roughnesses of the rocks in the rapids and waterfalls and of the wooden beams in the weirs. By hundreds of thousands they perish during the migration, but great multitudes of them reach their goal. Not even so mighty a hindrance as the Falls of Schaffhausen can keep them out of the Lake of Constance, whence they

continue their progress into the mountain torrents. Some of the travellers are two-year-old and three-year-old eels, which occasionally make their presence felt in a disagreeable way by entering gullies and water-pipes, and clambering into the houses even to the topmost storeys.

As soon as they enter the rivers, the young eels begin to eat and to grow, and, no longer transparent but opaque and coloured, are metamorphosed into " yellow eels ". Eels are voracious feeders. In youth they devour little crustaceans and worms, but as they grow larger they can deal with larger prey, so that even young rats and water-fowls have been found in their stomachs. But they have a special taste for hard roe, often attacking female fish that are entangled in nets, entering the sexual orifice and, beginning with the ova, eating up the mother fish from within. Sometimes eels leave the water and wander for considerable distances across damp meadows into remote ponds. It is an ineradicable folk-superstition that such eels plunder pea-plantations.

Notwithstanding their hearty appetite, eels grow slowly. The males remain slenderer and softer than the females, reaching a length of at most twenty inches, whereas the females may grow to nearly five feet in length. During the winter they bury themselves in the mud and hibernate. In this manner eels live seven, eight, or nine years in fresh water ; but even at the end of that time, and when the animals have attained a large size, the reproductive organs are still in an undeveloped state. By degrees, however, a striking change takes place. The eel's back assumes a darker tint, its belly a lighter one, and simultaneously the whole skin takes on a

metallic sheen. The eyes enlarge and become more prominent. Most important of all, the reproductive organs now begin to grow, while the gastro-intestinal canal dwindles. The period of high feeding is over, and that of sexual maturity is approaching. The eels are getting ready for the return migration to the sea.

Until recently, the subsequent life-history of the mature eels, from the moment when they disappeared into the ocean, was unknown. Their breeding-places eluded observation, and no one could tell whence their journey upstream had started and where their journey downstream came to a close. At length, however, during the last few decades, soundings have shown that sexually mature eels become deep-sea fishes with huge eyes, and that leptocephalus is not a distinct species but a larval form out of which, by a gradual transformation, the glass-eel develops. Leptocephalus is born thousands of miles from the starting-point of the nuptial journey, at or near the bottom of the Sargasso Sea that lies in the bight of the Gulf Stream midway between the Canary Islands and the West Indies. The details of the spawning, the characteristics of the ova out of which leptocephalus derives, and other important details still elude us. We do not know what becomes of the elderly eels after the sexual act—whether they speedily perish, or go on living for some time in the depths of the sea. The migrations of eels are even more enigmatic than the migrations of birds. Of what nature can be the sense of direction which guides the creatures so surely through the vast spaces of the ocean? The marking of specimens has shown that an adult eel can swim about ten miles a day, so that it must take them some eight months to

reach the Sargasso Sea from the mouths of western European rivers.

In the salmon we saw plainly that an active sexual impulse must already exist, although these fishes do not enter into intimate bodily relationships, and although the full meaning of the love-play escapes us. From this simple ejaculation of the semen upon the ova after their discharge by the female, from this mere covering of the fertilised eggs with a thin layer of sand, there is an unbroken series of stages leading to more and more intimate contact, to a complete bodily union in a copulatory act in which a virile member is introduced into the body of the female, and to an evermore elaborate system of caring for the brood. As we shall learn in due course, many fishes guard their young until these are fit for independence, even as a hen gathereth her chickens under her wing.

Among the lake-trout of Upper Bavaria, love-play is well developed. Greatly excited, pressing their abdomens together, the fish leap many feet out of the water, while simultaneously ejaculating the ova and the milt.

In pike, more intimate bodily contact occurs. Several males simultaneously press up against a female, rubbing their bodies against hers, lashing their tails vigorously while they discharge their semen.

In lampreys, an even more affectionate union occurs. The female wooed by a male, after a period of coyness, attaches herself to a stone by her sucker-like mouth. Then the male, swimming round his chosen mate, proceeds to cling to the female with his mouth applied to the back of her head, encircles her body with his tail, and, undergoing the most remarkable contortions,

manages to bring his sexual orifice into contact with hers, so that, although he has no copulatory organs, his milt is poured directly into the female sexual orifice.

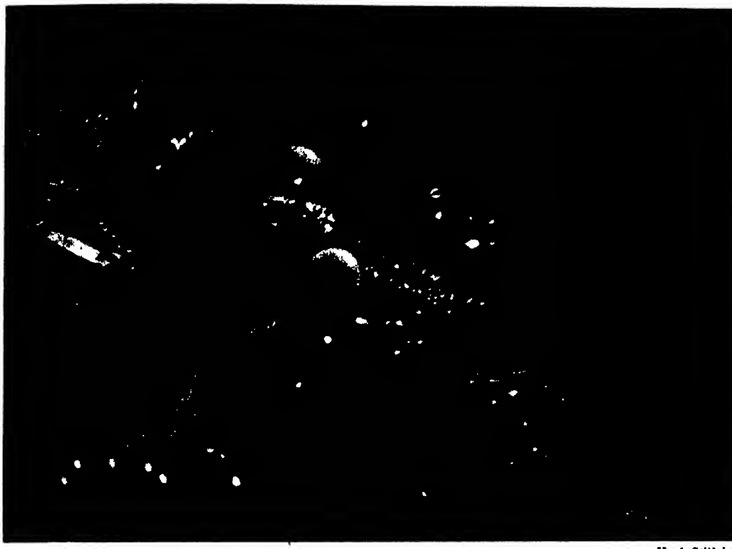
In Callionymus lyra, the Mediterranean lyre-fish, at the pairing season the male changes markedly in tint, putting on, so to say, a motley wedding garment. To begin with, the female and the male swim side by side over the sea-bottom. Excited by the proximity of the female, the male now assumes a yet more lively tint, especially upon the fins, and this display of colour obviously proves alluring to the female. One female after another leaves the shoal, to swim with the male she has chosen, who now folds his fins. For a while the pair move side by side. Suddenly, with a stroke of his pectoral fin, the male brings the anterior part of his body into a vertical position, while spreading his dorsal and anal fins. The female, too, now unfolds her ventral fin, likewise assumes a vertical position, and presses close up to the male, covering her partner's two ventral fins with her own single one. In this attitude the fishes rise to the surface and bring their anal fins into apposition, forming out of these a sort of duct through which the ova discharged by the female pass while simultaneously the male ejaculates his semen into the canal.

In the butterfly-fish, Pantodon buchholzi, a small fresh-water fish which lives in the rivers of the West Coast of Africa, the fins are very large, enabling it to leap out of the water and, looking like a small dragon, to fly or soar for a considerable distance up-wind. The rays of the ventral fin are greatly elongated, so that these fins look like hands with the fingers outstretched. At the pairing season, the male climbs on the female's

back and clings to her with these "hands". The animals remain thus clasped for many hours, in a position that is only the prelude to the sexual act, for during it no spawning takes place. At length the male liberates the female from his embrace. With continual changes of colour from light tints to deep black, the two fishes circle round one another in an ever-swifter waltz, until the female begins to eject her ova. Thereupon the male thrusts his anal fin beneath the female's belly and ejaculates his semen.

What is in general terms spoken of as love-play is not always playful, is by no means invariably peaceful. It would be juster, in many instances, to talk of a love-combat. Everyone knows how in many mammals the males at the rutting season fight furiously for the possession of the females, and that these joustings may result in the death of one or both rivals. Stags, for instance, sometimes get their antlers inseparably locked, and perish miserably of starvation. The females usually assume an attitude of comparative indifference to such love-wrestles—or may, as we have already mentioned in the case of does, seize the opportunity of submitting to the embraces of another lover.

Remarkable pugnacity and ruthlessness are displayed by the macropods (fighting-fish, Betta splendens), those most amusing among the regular inhabitants of aquariums, fish in which both sexes at pairing-time assume resplendent colours. Among these creatures the preliminary love-play sometimes lasts for several weeks, the male circling round the female with his fins spread wide and puffing himself out like a turkey-cock. That matters are approaching a crisis, that the real act of pairing is close



Karl Stülcken

FIG. 26.—EDIBLE FROG, WITH EXTRUDED BLADDERS

Karl Stülcken

FIG. 27.—TOADS COPULATING

at hand, becomes apparent when the male begins to build a peculiar, floating nest for the reception of the ova. Rising to the surface, he swallows air, and then expels little bubbles sticky with mucus. These gradually form a coherent mass of such bubbles which is several layers thick. While the nest is a-building, the male and the female may at intervals engage in a little love-play; but if the female should venture to approach the nest before it is finished, she will be very roughly treated by her partner, so roughly that she sometimes dies of her wounds. The male macropods are also very combative among themselves, tearing one another's fins, splitting up one another's mouths, and even at times destroying one another's eyes. The females, no less, are at this season fiercely jealous, and fight like furies.

When, at length, the nest is ready and when the female is "ripe" for the depositing of her ova (this being shown by the way in which she affectionately circles round the male, presses up against him, and again and again nuzzles his abdomen), she can without danger approach the structure of bubbles, and here, immediately beneath it, the act of sexual union takes place. The male encircles the female with his body, so that his head and his tail meet above his mate's back, and he pushes her upward. The "embrace" grows tighter, and probably the pressure the male exercises tends to press out the ova, which are bathed with milt the instant they emerge. Since the ova are lighter than water, they rise and cling to the under-surface of the bubble-nest. Should any of them sink, the male lifts them in his mouth and carefully attaches them to the under-side of the nest. Coupling in this fashion is repeated several times a day, until a

good many hundred ova are clinging to the nest. When the spawning is over, the female's work is done. She no longer troubles herself about the nest, whereas the male is continually fussing round it. When the little fishes hatch out, he watches over them, and fiercely drives away all their enemies until they are big enough to take care of themselves. Thereupon, however, his paternal affection dies down, and he will not hesitate to eat his own offspring unless they seek safety in flight. (See Fig. 18 on plate facing p. 112.)

A similar attitude in pairing is assumed by sharks of various species, as is plainly shown by our illustration of two dogfishes, Scyllium canicula, coupling. (See Fig. 19 on plate facing p. 112.) The female rests upon the sea-bottom, usually with her body fully extended, while the male caresses her, encircling her with his own strongly bent body. While the pair is in this position, the male and female sexual orifices, situated immediately behind the ventral fins, are pressed closely together, so that the milt is ejaculated into the female reproductive orifice. The transference of the semen is facilitated by the formation of special copulatory organs in the males. These virile members or pterygopodia, are very variously shaped in the different types of shark, but have this in common that they all arise by a metamorphosis of part of the ventral fin, which is elongated into a furrowed or tubular coupling organ through which the milt flows into the female sexual orifice.

In the most widely separated classes of animals we find the extremities so transformed that they serve, not only to hold the female firmly in a sexual embrace, but also, with modifications of an extremely characteristic

nature, as implements for the direct or indirect transmission of the semen. Such extremities or appendages metamorphosed into canals for sperm are met with, for instance, in many of the millipedes, and are common in the higher crustacea.

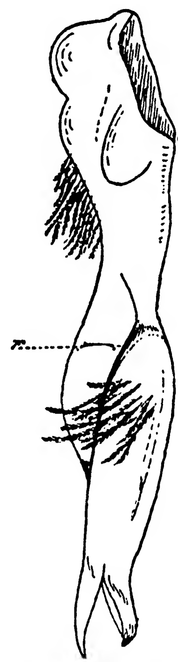


FIG. 28.—FIRST ABDOMINAL APPENDAGE OF ONE OF THE HIGHER CRUSTACEANS (CAMBARUS AFFINIS) MODIFIED FOR THE TRANSMISSION OF THE SPERM. (*After* ANDREWS.)

r, longitudinal furrow.

Among the crustacea we often find that sexual intercourse is effected in a position that is comparatively rare in other animals, except for human beings, since it is that adopted by various savage races. Consider, for instance, Cambarus affinis. The male seizes the passive or resisting female and flings her roughly upon her back.

Then, himself adopting a semi-upright position, he holds her fast with hook-shaped processes projecting from the third pair of abdominal appendages, these fitting into furrows in the female's carapace. Simultaneously the male, spreading his tail wide, hooks it over the female's abdomen which is bent upward upon itself, and proceeds to apply to her sexual orifice his anterior abdominal appendages which have been modified on each side by the production of a furrow. Along this furrow his

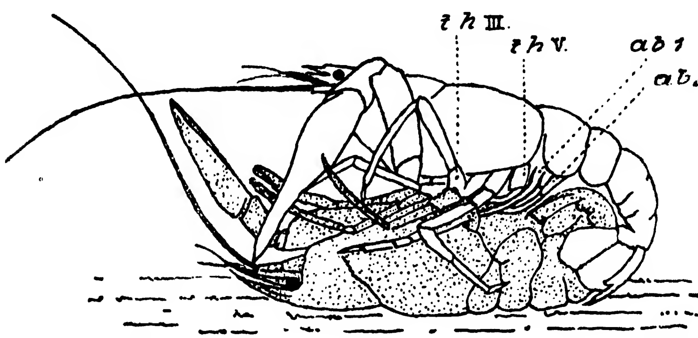


FIG. 29.—ATTITUDE OF A PAIR OF HIGHER CRUSTACEANS (CAMBARUS AFFINIS) DURING COPULATION. (*After* ANDREWS.)

Above is the male, and the female lies beneath him on her back. *ab*1 and *ab* 2 are the anterior abdominal appendages modified for the transmission of the semen. *th* III and *th* V are the third and fifth thoracic legs.

semen flows. Matters have not, in this creature, gone so far as to provide for the introduction of a copulatory organ into the interior of the female's body. (See Figs. 28 and 29.) This position of cambarus when coupling is closely akin to the attitude which, as we shall learn in the last chapter, is preferred for coitus by the indigenes of many of the South Sea Islands and by the Australian blackfellows. (See Fig. 30.)

Another peculiar modification of the limbs occurs in many spiders for the transmission of the sperm, the

maxillary palps, which are a long way from the sexual orifice, bearing on their terminal segments a bottle-shaped or pear-shaped appendage which varies much from one species to another. Shortly before the act of intercourse, the male fills these little bottles of his with the sperm flowing out of his sexual orifice, and then, after a shorter or longer period of love-play, he empties his semen-containers into the reproductive orifice of the

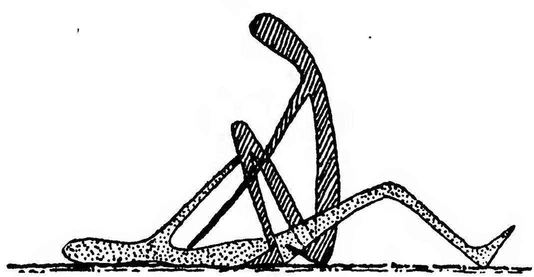


FIG. 30.—POSITION OF AUSTRALIAN ABORIGINES IN COITUS. (*After* MIKLUCHO-MACLAY.)

female. In the next chapter, we shall have to consider the loves of the spider in fuller detail. (See Figs. 38 and 40.)

The tentacles of cuttle-fish find a still stranger use as copulatory organs. As a rule, of the eight arms of the octopods, or of the ten arms of the decapods, only one, but in exceptional cases a pair, will be found to have been modified into a copulatory apparatus, termed the hectocotylus. The metamorphosis consists mainly in this, that the suckers have degenerated or completely disappeared, and that along the middle of the tentacles there runs a furrow, down which the masses of sperm (which in the cuttle-fish are often compacted into peculiarly formed semen-cartridges or spermatophores) are carried

by muscular contraction. In the common squid, Loligo vulgaris, which abounds in the Mediterranean and is occasionally met with in the North Sea, the male, swimming underneath the female, clasps her with his tentacles, and, when in this position, thrusts his hectocotylus into her mantle-cavity, having previously armed it with spermatophores at his own sexual orifice. All this takes but a few seconds, and immediately after the spermatophores have been deposited, the pair fall apart. Within the body of the female the spermatophores, the semen-cartridges, explode, in the literal sense of the term, the

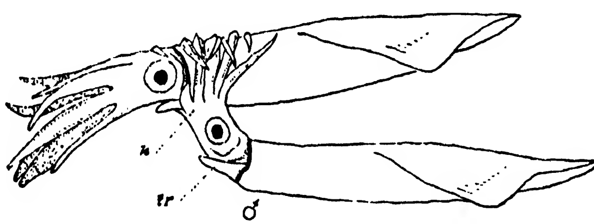


FIG. 31.—CUTTLE-FISH (LOLLIGO PEALLI) COPULATING.

Above is the female. Below is the male, embracing her with his tentacles. *h*, the male's hectocotylus, which has been introduced into the mantle-cavity of the female. *tr*, infundibulum of the male.

spermatozoa filling the mantle-cavity and the infundibulum, and penetrating the ova as they emerge. (See Fig. 31.)

Octopus vulgaris is far more leisurely in the love act. The female and the male draw close together, the female crouches down, the male, standing proudly erect, stretches forth his hectocotylus, slowly introduces it into the female's mantle-cavity, deposits his spermatophores there, and then, no less deliberately, retracts the organ. (See Fig. 32.)

Indeed, this hectocotylus may even make itself independent, and complete the act of sexual union without

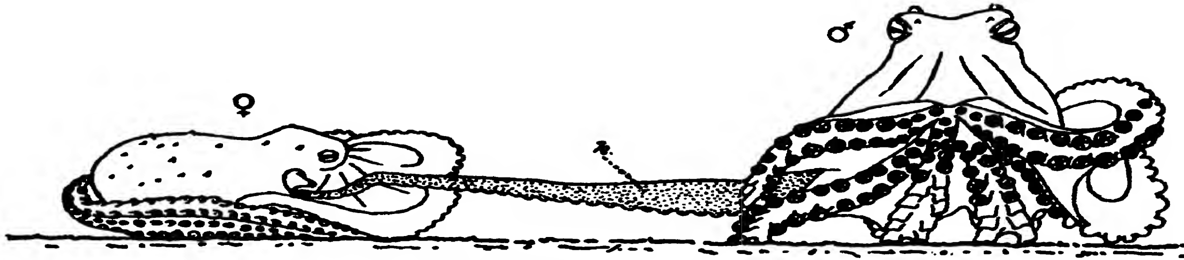


FIG. 32.—THE COMMON OCTOPUS COPULATING.
h, hectocotylus of the male, introduced into the female's mantle-cavity.

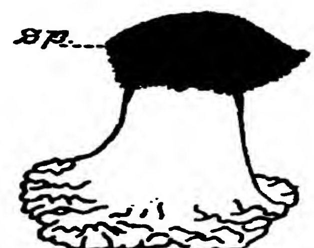


FIG. 33.—SPERMATOPHORE OF A WATER SALAMANDER (AMBLYOSTOMA PUNCTATUM). (*After* SMITH.)

the co-operation of the male individual. One could almost say, when this happens, that the male has at length lost his contrectative impulse, having transferred it to his detachable copulatory organ. This remarkable phenomenon is seen in the paper-sailor or argonaut, Argonauta argo. In these creatures, the hectocotylised tentacle has been greatly modified, differing even in its earlier stages of development from the other tentacles, inasmuch as it is, in the period of growth, surrounded by a pear-shaped membranous bladder, of which it is only divested when sexual maturity is attained. On the bursting of the bladder, this peculiar tentacle is liberated, except for its slender stalk which attaches it to the body.

The stalk of the hectocotylus is extremely slender, so that it can easily be broken, but the organ itself is several times longer than the body of the animal. In the paper-sailor, the male has not yet become so indifferent to the joys of sex as to renounce copulation altogether, for on its own initiative it introduces the hectocotylus deep into the gill-cavity of the female. Thereupon, however, the male reproductive organ breaks off where its pedicle is thin, and remains inserted in the female sexual orifice. There are, however, other kinds of nautilus in which the hectocotylus becomes detached from the male which bears it, and sets forth to swim with the aid of serpentine movements in search of a female. Having found one, it thrusts itself, on its own account, into the latter's mantle-cavity. If you want to realise the full grotesqueness of the operation, you have only to conceive the same sort of thing occurring in a mammal! [The folk-imagination is capable of this feat. Graffiti are sometimes

to be seen on the whitewashed walls in rooms of houses in course of completion, depicting a winged penis and testicles, flying through the air towards an expectant female.] Such remarkable independence of a copulatory organ misled earlier investigators, especially in view of the fact that the hectocotyli retain their power of free motility for a considerable time after having been set at liberty. The first observers to discover these remarkable structures in the mantle-cavities of female nautiluses (sometimes a number of hectocotyli will simultaneously be engaged in fertilising one female) regarded them as parasitic worms. It was not until some time afterwards that their true nature was recognised.

A very active wooing occurs among many amphibia, as for instance in the crested salamander, Molge cristata, and its numerous congeners, although actual copulation does not occur. At the mating, the crested salamander (like many of the organisms previously described) indues a fine wedding garment. Its belly turns a vivid yellowish-red; upon the side of the tail a mother-of-pearl band shading into blue is seen; the head is mottled like black marble; and on the back of the body and the tail there develops a crest which is almost as high as the width of the body and is only indented at the root of the tail. So much for the male. The females have no crest, but their tints become livelier. The male steadily pursues the female, both on land and in the water, nuzzling his mate and showing off his beauties, until at length the bride responds to his wooing, and in her turn is ready to follow his lead.

Now the male crawls slowly, and, as it were, thoughtfully, along the bottom of the water, with the female

hard at his heels. Suddenly, with a peculiar kinking of his body, he deposits beneath him a spermatophore which crowns a little mass of quaking jelly attaching it to the ground (see Fig. 33) and crawls on his way. His mate, pursuing his trail, brings her sexual orifice directly over this spermatophore. Then she crouches down so that the spermatophore, becoming detached from the gelatinous stem, cleaves to her cloacal fissure. Thereupon the spermatophore breaks up, and the spermatozoa penetrate the female sexual orifice. This process is repeated several times.

We find exactly the same method of transferring the semen in two animals belonging to an entirely different class of the animal kingdom, namely the pseudo-scorpions, Chernes cyrneus and Chelifer cimicoides, in which the male likewise attaches spermatophores to the ground by means of a long thin stalk, at the top of which they sway to and fro. In the case of these scorpions, however, the male is not content to pursue his own course after depositing the spermatophore. Instead, he begins by seizing the female's claws in his own, next deposits his spermatophore, and then proceeds to walk backward, dragging his mate forward until her sexual orifice is brought into a position immediately above the spermatophore. Thereupon, by a snapping movement of the edges of the female sexual orifice, the little parcel of spermatozoa is, so to say, swallowed. (See Fig. 34.)

Among toads and frogs there occurs an intimate coupling of the sexes which lasts for several days, and yet there is no act of coitus in the proper sense of the term. The male climbs on the female's back, and sits there clasping her in his arms. When, at length, the

female expels her ova (which are often tied together in long strings), he ejaculates his semen over them. While thus clasping the female with the aid of the enlarged thumbs which swell markedly in the breeding season, he presses his wife's body so forcibly as to assist in the expulsion of the ova, and thus functions as an accoucheur. (See Fig. 27, on plate facing p. 144). By these violent embraces he sometimes inflicts fatal injuries on the female. The mating impulse of frogs and toads is so

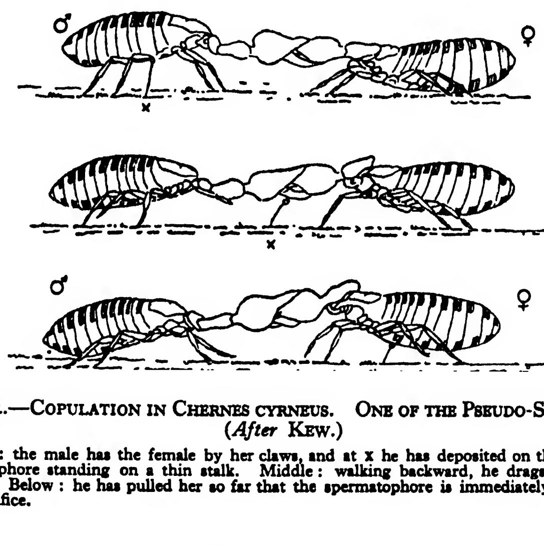


FIG. 34.—COPULATION IN CHERNES CYRNEUS. ONE OF THE PSEUDO-SCORPIONS. (*After* KEW.)

Above: the male has the female by her claws, and at x he has deposited on the ground a spermatophore standing on a thin stalk. Middle: walking backward, he drags the female forward. Below: he has pulled her so far that the spermatophore is immediately under her sexual orifice.

powerful, that the males, if they do not come across a female of their own species at the appropriate time, will clasp other creatures, even fishes, or a human hand, in the endeavour to achieve an act of sexual congress—this showing that in perfectly natural conditions there may be aberrations of the sexual impulse of a kind which, when they occur among human beings, are condemned by moralists. Pæderasty is in fact an occasional aberra-

tion in almost all classes of animals, and in some of them is common, so that we have no right to regard it as merely a degenerative phenomenon resulting from civilisation. No doubt, such sexual aberrations are more apt to occur in domesticated animals, and in wild animals that are confined in zoological gardens and menageries. As regards the aberration which in human beings is termed bestiality (copulation or the attempt to copulate with creatures of a very different species), this is to a large extent prevented by nature—among the insects, for instance—by such marked specific differentiations in the male and female coupling organs that intercourse even with species that are closely akin is impossible.

The foregoing instances must suffice. They show clearly how the sexual impulse has gradually developed out of what was originally no more than an impulse to evacuate the reproductive products; and also what widely divergent paths nature may follow to attain one and the same end—the fertilisation of the ovum. When, however, circumstances render the change favourable to the preservation of the species, the sexual impulse may undergo transformation and reversion, so that not merely is coupling renounced but even fertilisation. The rôle of the male in the life of the species may become continually less important, males ceasing to appear for many generations or altogether, and the females becoming progressively more emancipated. In the next chapter we shall consider this emancipation of the female sex.

CHAPTER SIX

THE EMANCIPATION OF WOMAN

IN this chapter we shall have to consider widely diversified phenomena and vital processes, which have, however, a common element. They all show females becoming dominant, males being forced into an inferior position in which they serve only as coupling-machines. There is formed, in a sense, a sex of amazons. Although these amazons continue to tolerate the approaches of the male, as soon as pairing has been effected the life-purpose of the latter has been fulfilled, and they are swept out of the way as superfluous feeders.

Nay more, the emancipation of woman can go further still. Ova primarily destined for fertilisation with male sperm can acquire the capacity of developing parthenogenetically. Thereupon the rôle of the male as a sexual partner indispensable to procreation has been played out. The males become much less numerous than the females ; and in many instances, as we have already learned, degenerate into a dwarf type. When this development is pushed a stage further, there arise purely feminine generations, which succeed one another again and again, though periodically, and sometimes at long intervals, an alternate generation in which the sexes are once again distinct may appear. In not a few instances, the male sex completely disappears.

The development which created two distinct sexes,

which divided the species into sexual individuals of two different sorts, into the females that play a passive and receptive part and the males that play an active and donative part; the development which awakened a sexual impulse in these two sexes, and which produced the almost infinitely diversified apparatus for the increase and gratification of the contrectative impulse—this development has now been reversed, until the male sex has been suppressed and the sexual impulse has been eliminated.

In general the female sex is coy, the sexual impulse of females having to be artificially awakened by the wooing of males. At first the female endeavours to avoid sexual intercourse by flight, and sometimes there is a struggle between the sexes. Only by degrees does the female's resistance weaken, until, at length, she yields to the impetuous male's onslaught and patiently surrenders to her fate. In other cases, after a good deal of preliminary love-play, an active impulse towards coupling arises also in the female. She responds to the male's caresses with caresses of her own, may become more eager than he, and may demand reiterated sexual gratification. This applies to many of the lower animals as well as to human beings.

The legend of the amazons tells us that, since men were indispensable to the continuance of the species, the warlike viragoes had intercourse with prisoners of war, but slew their mates as soon as the act of kind was over. So likewise among those lower animals in whom the females avenge their incapacity to reproduce without the aid of males and their enforced surrender to the other sex by slaying their husbands as soon as sexual congress is finished.

Among these animal suffragettes, most of the spiders must be numbered. Like the amazons, they have not yet succeeded in emancipating themselves completely from males. Their eggs cannot develop in default of fertilisation. The male remains for them a necessary evil, indispensable to the preservation of the species. But as soon as copulation has been effected, the husband is devoured by his spouse, if he does not succeed in eluding her by a hasty flight. The inferior position of the male among the spiders finds plain expression in the fact that many spiders are polyandrous, the biological explanation probably being that a good many males fall victims to the blood-lust of their wives before a successful act of intercourse takes place.

In the majority of spiders there is well-marked sexual dimorphism. The males are notably smaller and weaker than the females. In some spiders, the difference in size is so great that we can speak of dwarf males. In Nephila nigra, a spider found on the island of Réunion, the female is nearly two inches long, whereas the male is only about one-fifth of an inch in length, and his body-weight is only about one six-hundredth of the female's. These tiny males usually live in pairs a sort of parasitic life upon the body of the female Nephila. In view of the extreme voracity displayed by most spiders, which are inclined to devour any insects they come across, sparing only their own offspring, the state of affairs that prevails in Nephila is remarkable. A plausible explanation of the immunity of the male Nephilæ is that the young of this species likewise pass their time crawling about their mother's body, and that the dwarf males are spared because they are of about the same size as the brood. Apart from the differ-

ence in size between males and females among the Nephila, the males are distinguished by a very marked development of the maxillary palps, the enlarged terminal segment of the palp having a seminal pouch concealed within its interior, or bearing attached to its side (in other species) a little spermatocyst or seminal vesicle of a peculiar bottle-shaped appearance. (See Fig. 38.) The coupling of these and other spiders is effected, not by the direct apposition of the sexual orifices which, in both male and

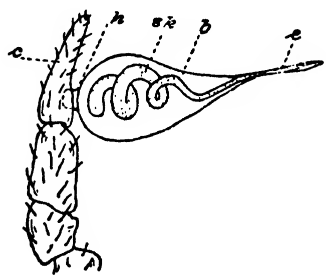


FIG. 38.—MAXILLARY PALP OF THE MALE CAVE-SPIDER, SEGESTRIA SENOCULATA, WITH ATTACHED SPERMATOCYST.

c, terminal segment of maxillary palp. *h*, attachment of spermatocyst. *sk*, spiral filament. *b*, spermatocyst or seminal vesicle. *e*, excretory duct.

female, are situated on the lower side of the abdomen, but through the intermediation of the maxillary palps.

On the approach of sexual maturity, the male spider spins a peculiar little sperm-net, which, in its simplest form, consists of three main ribs radiating from a point, and in the angle between two of them a triangular web. (See Fig. 39.) As soon as the net is ready, the male ejaculates a drop of seminal fluid upon the upper surface of the web. Then he betakes himself to the lower surface, or thrusts his maxillary palps beneath the net, whereupon the seminal vesicle, first of one and then of the other maxillary palp, is filled with the ejaculated semen,

Dr. Kurt Priemel

FIG. 35.—A KLIPSPRINGER SHOWING A CONSPICUOUS RUT-GLAND BELOW THE EYE

Käthe Hecht

FIG. 36.—ROEDEER ENGAGED IN LOVE-PLAY

Carl Hagenbeck

FIG. 37.—GOLDEN PHEASANTS AT THE MATING SEASON

which makes its way through capillary attraction into the narrow tube. Thus equipped, the little male sets forth upon his love-adventure, a hazardous journey, which is likely to end in his death, sometimes before and sometimes after coupling. In the garden spider, Epeira diademata, this strange method of wooing, which, with greater or lesser variations, is common to nearly all the spiders, can be easily observed. (See Fig. 20 on plate facing p. 113.)

Everyone is familiar with the beautiful polygonal net

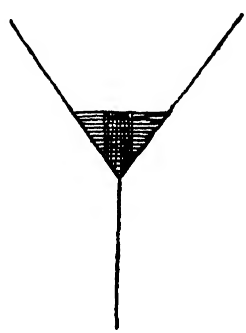


FIG. 39.—A SPIDER'S SPERM-NET.

of the garden spider. The male sets out on the search for a female early in the morning, and as soon as he comes across the net of a female, he begins by attaching a thread to it as " a bridge of life and love ". By twitching this communication-cord, he seeks to attract the attention of his lady-love. What now happens depends upon her caprice, which is probably determined by whether she is fasting or well-fed. Often the female, at the first twitch, flings herself upon her would-be husband, seizes him, carries him off into her nest, and sucks his juices—unless the male, realising his danger in time, escapes by a life-

line. Still, even so rough a reception does not discourage the little husband. He attaches another love-thread, and gives a fresh twitch. If the female refrains from a second fierce onslaught, the male cautiously approaches her, all his legs a-tremble, while he makes rhythmic movements with his abdomen. In his deprecatory advances, he assumes the most farcical attitudes. His excitement and his twitching at the thread grow more violent, until at length the female is moved to respond. Drawing near to the male, and holding on by the claws of her hindlegs to the bridge of love, she hangs head downwards, so that her abdomen is turned towards the male. For him this is a signal to relinquish caution, and boldly to march upon his beloved. There ensues a lively caressing of the wife's body by the husband's legs, she being a consenting party. Sometimes, even then, hunger gets the better of her sexual impulse, and she eats her lover before he has completed the act of coupling. In general, however, the love-play lasts several minutes, and seems to have a hypnotising effect upon the female. At length the male considers that the favourable moment has arrived. He thrusts his maxillary palp deep into the female's sexual orifice, the sperm flowing into a special receptaculum seminis, which in most spiders opens by a separate orifice close to that of the vagina, and by an extrusion of semen from which the eggs are fertilised as they are laid. Now the male must seek safety in precipitate flight, unless he wishes to pay with his life for having yielded to the promptings of the sexual impulse. During the rapid withdrawal of the maxillary palp, it often snaps, or its terminal segment breaks off and remains in the female's sexual orifice as a " token of

copulation ". (See Fig. 40.) Such tokens of copulation are found in other animals, as for instance in the queen-bee, for bees engage in a complete act of coitus, at the end of which the drone's penis breaks off. The queen returns to the hive with the token of copulation in her body, while the drone bleeds to death. In this case the breaking-off of the penis subserves an important biological purpose, for, the severed organ, acting as a plug, prevents the outflow of the semen through the female sexual orifice, which will inevitably occur if the token of copulation be prematurely removed.

Such a corking of the vagina when coitus is over

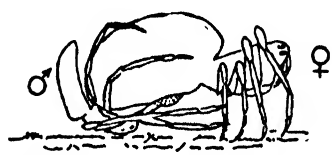


FIG. 40.—XYSTICUS STOMACOSUS (A SPIDER) COPULATING.
The male (beneath) is in the act of thrusting his maxillary palp, equipped with a spermatocyst, into the sexual orifice of the female.

may be achieved in another way. Among many rodents there are specialised glands adjoining the seminal vesicles, and the secretion of these glands, mixing with the semen during ejaculation, causes the fluid to coagulate, so that the female sexual orifice is securely closed.

But perhaps the strangest way of preventing " profluvium seminis " is that met with in dogs. At the lower end of the glans penis are two masses of erectile tissue, part of the corpora cavernosa, which produce marked lateral prominences of the organ at the time of maximum erection. (See Fig. 62.) When the dog first introduces his penis, the organ is quasi-cylindrical, but, speedily

after introduction,' these " nodes " become greatly enlarged and distend the vagina of the bitch. As soon as the swelling has set in, the dog is unable to withdraw his penis until erection has completely subsided. After the orgasm has taken place, the dog turns round, and he and the bitch stand stern to stern, sometimes for nearly as long as an hour, until the " locking " is over. Throughout this period ejaculation is going on, but only at first does the ejaculated fluid contain spermatozoa. During the later phases of the " lock ", what flows into the vagina is a sperm-free secretion which drives the semen proper farther and farther into the uterine orifice of the bitch, and thus ensures fertilisation.

Although spiders are bad wives, they are devoted mothers, carrying their packet of eggs about with them, and when the young spiders have hatched out, bearing their offspring on their back for a long time and defending the little creatures against all attacks. (See Fig. 21 on plate facing p. 113.)

In many spiders a remarkable device is employed for the diffusion of the species. The young join the air-force, become bold aviators and traverse considerable distances as aerial gliders. We see this, for instance, in the crab-spider, Xysticus viaticus, which makes gossamer—the delicate threads which fill the air in autumn—and, when the aerial course is over, these threads form a thin vesture for the twigs, the grass, and the hedges. Every one of the filmy webs is the airship of a young crab-spider, in search of a new dwelling-place. Lifting its abdomen high in the air, the young spider spins a thin thread, which grows longer and longer and streams down the wind. As soon as the filament is long enough, and has

sufficient lifting capacity, the spider clings to it and sails off upon the breeze.

There is one of the spider kind which leads an exemplary married life, and this notable example must not be forgotten. I refer to the diving-spider, Argyroneta aquatica, the only spider in this part of the world which has adapted itself to an aquatic life, building its silvery sub-aqueous nest in our ponds and ditches. The diving-spider is sharply distinguished from almost all other spiders by the fact that the males are about twice as big as the females. These big males would hardly submit to such unceremonious treatment as ordinary spiders receive from their wives. The abdomen of the diving-spider is set with fine hairs, and is always surrounded by a thick envelope of air entangled in these hairs, enabling the creature to breathe under water. Among the stems of aquatic plants the argyroneta weaves a bell-shaped structure with thick walls, the threads being so felted together as to be impervious to air and water. It is made with the bell-mouth opening downwards. As soon as the nest is finished, the spiders swim to the surface of the water, stretch the abdomen and the crossed hind-legs above the surface for a moment, and dive back with a fine bubble of air clinging to the spinnerets. This bubble they discharge beneath the bell-shaped nest. The action is repeated until the nest is filled with air. As a rule male and female build separate bells, but those of the members of each pair are connected by a passage.

It is in these nests that they live a happy married life, and it is here that coupling takes place. The fertilised ova are affixed to the inside of the roof of the nest, so that

the young spiders have protection and concealment from their earliest days.

Whilst among most spiders the males that go a-wooing are apt to be the victims of their wives' voracious appetites, in the case of the praying mantis, the devouring of the husband by the wife has become an established rule. The Mantis religiosa of southern Europe, a cousin of Mantis oratoria, is found also in south-west Germany. There is a marked sexual difference in size among these creatures, the strongly built and powerful female attaining a length of as much as three inches, whereas the slenderer males seldom reach two inches in length. The name of " praying mantis " is derived from the peculiar attitude of body they assume, and from the position adopted by the front legs when the creatures are on the watch for food. The front legs have undergone a metamorphosis into formidable trap-like structures. The femur and tibia have toothed edges, between which insects can be seized and crushed. A mantis will sit for hours upon its hind-legs with the body erect and with the prehensile arms raised motionless above the head like hands at prayer. As for the head, which has large compound eyes and long antennæ, this can be turned on the long neck almost in a circle. The male has to be extremely adroit if, without being torn to pieces, he is to climb upon his wife's back and introduce his penis. That is his last indulgence, for as soon as the act of coupling is over, he will infallibly be seized by his wife's shears and devoured. (See Figs. 24 and 25 on plate facing p. 128.)

The female mantis does not seem to experience any marked pleasure during the sexual act, or at any rate her murderous instinct and her hunger will often overpower

a desire to pair. I have myself kept these creatures in a terrarium, and have watched the wife seize her husband during the very article of copulation, and begin to eat him while the husband persisted for a time in the performance of his marital duties. Other observers have reported that a male whose head and part of whose thorax had been torn off by the female during the first approaches, has been able, disregarding his wounds, to succeed in impregnating his murderous spouse. Many female mantises are so savage that the only way of keeping a male or two alive with them in the terrarium is to tie up the front legs so that the trap-like apparatus is put out of action.

Incredible as it may sound, this persistence of a severely injured male in fulfilling his sexual impulse is explicable on the ground that these animals seem to have very little sense of bodily pain, and are endowed with an extraordinarily tough vitality. We see similar characteristics in the closely related grasshoppers and crickets, which have a trick of self-mutilation. If you pick up a grasshopper in your fingers you will often find that it will suddenly, and indeed with lightning swiftness, seize its front legs in its own jaws and bite them off—a protective measure analogous to the breaking-off of the tail of a lizard, whereby the animal tries to escape being taken prisoner. But such mutilations can go much farther and lose any biological significance. I had under observation in my terrarium some captured leaf-grasshoppers. They seemed in good condition, until I noticed that some of the limb segments were lacking, and that the insects had severe wounds on the abdomen. Watching them closely, I perceived that these injuries were self-inflicted. Without apparent cause (since they were liberally sup-

plied with food), they began, quite contentedly it would seem, to eat themselves up. At first the feet and legs were gnawed off; then, in the case of the females, the ovipositor was attacked; and at length the creatures began biting their own abdomens. Once they have tasted their own flesh, they seem to find it so delicious that they will take no other food, and nothing but death will end the work of self-destruction.

In the stick and leaf insects, or phasmidæ (sometimes known in the vernacular as "spectres"), which are closely allied to the mantidæ, the males are not devoured by the females, but it is plain enough that the "stronger" sex is on the down grade. In a good many species of the phasmidæ, males and females are still produced in equal numbers; but in other kinds, for instance in Rossi's stick-insect (Bacillus rossi), males are a rarity. These creatures can readily be bred in a terrarium, where, when males are wanting, the females lay abundant eggs, which develop parthenogenetically. In some species of phasmidæ, the males seem to have disappeared, or are at any rate so rare that no male has hitherto been seen. This statement applies to another stick-insect, Bacillus gallicus. In other orders of the animal kingdom, as among the gall-flies, the lower crustacea, butterflies, and beetles, we find species in which there are very few males, or in which the males seem to have vanished altogether.

A hand is formed to grasp; a heart, to pump the blood through the body; a lung, for respiratory purposes; a brain, to think; and a sexually specialised animal, to fulfil its function in a conjugal union with a member of the same species but of the opposite sex. Still, just as, when the conditions of life vary, the functions of various

organs can be affected, or just as an organ may atrophy when it has become superfluous, so can the function of sexed animals be modified. There may, in a species, be creatures which have many of the distinctive marks of one sex or the other, but which no longer fulfil the function of reproduction. The perpetuation of the species is reserved for specific individuals, fully developed in the sexual respect, whilst the other members have other duties assigned to them, and, in conjunction with a more or less marked degeneration of their sexual organisation and function, often experience profound transformations. In extreme cases, instead of being independent individuals, they become mere organs of a conjoined organism. The minor degrees of this transformation are realised among the social insects ; the major degrees, among the siphonophora.

I have already referred several times to the small fresh-water polyp hydra, which may reproduce itself in either of two ways, asexually by budding, or sexually by the union of ova and spermatozoa. In the marine kindred of this fresh-water polyp, the buds often remain connected with the maternal body, with the result that beautiful branched communities are formed, composed of numerous individuals. The individuals composing such a joint organism are obviously in organic connection one with another through their common gastro-intestinal canal, and the food which one of these " individuals " devours is useful, not only to itself, but to all the members of the tribe. In many species the polyps of such colonies are, as regards their essential structure, very like hydra ; but they have lost the power of producing reproductive organs, and can only multiply asexually—by budding.

The community as a whole, however, is able, besides enlarging itself by budding, to produce (also by budding) free-swimming sexual creatures, known as medusæ, which are but polyps modified for the purposes of a free life. These medusæ break away early from the community, and, in their bell, sexual organs ripen. Out of the fertilised ova of the medusæ, larvæ proceed, take root, and transform themselves into polyps, which bud to produce a community by asexual generation, and then, after a while, send forth a new, this time a sexual generation of medusæ.

The formation of free sexual creatures, carried by the winds and the waves and also by the power of independent movement through great distances, being thus enabled to disseminate their sexual products far and wide, is of the utmost importance to the preservation of the species and to the conquest of new areas for habitation. We further see herein an additional way of preventing, in the case of animals that have adopted a fixed life, the dangers of breeding in-and-in. Many species, however, as for instance the lovely sertularidæ and plumularidæ, have, strangely enough, forgone the advantage of producing freely motile sexual individuals. It is true that they continue to bud forth a medusa generation, but in these medusæ the motile bell and most of the other organs have regressed, so that the medusa buds are nothing more than sexual organs attached to the main stem.

Yet another line of development has been taken by the siphonophora, community-forming oceanic hydrozoa which are unattached, and are among the most beautiful specimens of pelagic animal life, forming, as it were,

brightly coloured flower-garlands, in or upon the surface of the sea. In these animals, the division of labour and the consequent transformation or degeneration of the individual members of the colony into mere organs of a community, has been carried to an extreme. Some individuals of the tribe are modified into swimming-bells, others into polyps which are mere mouths, others into thick protective portions which have no internal organisation left, but serve only to shelter the organ-individuals lying beneath; yet others have been metamorphosed into long tentacles beset with swinging threads; and yet others, finally, into male and female reproductive organs. The transformation of the individual members has gone so far that a colony of siphonophora gives the impression of being a unified organism with a number of organs specialised for different functions.

In the honey-bee, Apis mellifica, one of the best known among the social insects, there has occurred a well-marked polymorphism of the citizens, dependent upon the division of labour—although polymorphism has not gone nearly so far as in the siphonophora. What interests us chiefly in this book is the degeneration of the sexual individuals, which, in the bees, chiefly affects the females. Only one female in a hive, the queen-bee, is developed into a normal female capable of being fertilised, whereas the other females remain sexually undeveloped, being specialised as worker-bees. As for the very numerous male bees or drones, all of which are fully developed in the sexual sense, only one succeeds in copulating with the queen, and, as previously explained, has to pay for this privilege with his life. Still, he does

not lose much in this respect, seeing that, as soon as the fertilised queen returns to the hive, the other males are slaughtered by the workers as superfluous mouths and their corpses are thrust out of the hive. Among the bees, another strange phenomenon occurs. The queen can lay fertilised or unfertilised ova as she pleases. The unfertilised ova develop only into drones; the fertilised ova are potential females, and by special treatment can be grown into queens, but the vast majority of them are destined to become the atrophic females known as workers.

A bee community consists, on the average, of about fifty thousand citizens, most of whom are worker-bees; a few hundred, or sometimes several thousand, being males or drones; and only one of them being a queen-bee. The drones can be easily recognised by the stocky, rounded shape of the abdomen, by the huge faceted eyes which seem to make up most of the head and run together across the forehead, and by the large and broad antennæ. We see once more in the case of drones how males are apt to be equipped with better sense-organs than females—for sexual purposes. The drones have powerful eyes because, in the nuptial flight, which takes them high in the air, they must not lose sight of the queen-bee. The antennæ of the drones are also very richly furnished with sense-organs, sometimes spoken of as pore-plates, of which a drone has about thirty thousand, whereas a queen-bee has only four thousand. It is uncertain whether these pore-plates subserve the sense of smell exclusively or whether they are perhaps tactile organs as well; but there can be no doubt that the antennæ of many insects play an important part in enabling the respective

sexes to recognise one another. This has been proved beyond question by experiments on butterflies, for male butterflies whose antennæ have been cut off make no attempt to copulate.

Worker-bees and queen-bees have long, pointed abdomens, the abdomen of the queen-bee being about one-third as long again as that of the worker-bee. Workers have on their legs apparatus for collecting food, " pollen-baskets ", " wax-pockets ", and " brushes ". These are lacking in the queen-bee. On the average a queen lays round about a thousand eggs a day (sometimes as many as three thousand), her activities in this respect being only interrupted by the approach of winter. While laying, she is perpetually surrounded by a guard of honour consisting of workers, which respectfully make way for her as she moves about, frequently caressing her and licking her. In reality these attentions are not the outcome of affection or reverence for the head of the State. The workers are merely licking up the molasses-like excretion from the queen's body. Apart from her egg-laying duties, the queen has no function in the community, all the tasks within and without the hive, such as the building of the combs, the care of the young, and the collection of pollen and honey, being incumbent upon the workers. The queen is really a prisoner of her guards and is fed by them as if she were a baby.

Before the queen lays an egg, she examines the cell in the honeycomb to see whether it is in perfect order, then she turns round, thrusts her abdomen deep into the cell, and deposits there a small, bluish-white, elongated egg. In the smaller cells, destined for workers, the egg is fertilised before it is discharged, whereas in the larger

cells, destined for drones, unfertilised ova are deposited. In the large royal cells, likewise, fertilised ova are laid, to hatch out as females which, being fed with more richly albuminous food than the larvæ destined to become workers (the so-called "royal jelly"), will develop into completely sexualised instead of atrophic females—in a word, into queen-bees. In the case of a young queen, the time needed for the development of the imago is sixteen days from the laying of the egg, whereas in the case of workers it is twenty-one days, and in the case of drones twenty-four days. The workers see to it that young queens shall emerge at stated intervals, not simultaneously. If the old queen dies in a hive which happens to be devoid of royal larvæ or young workers' larvæ, it becomes "drone-broody", this meaning that the workers can also in case of need lay parthenogenetic eggs—but since these eggs are unfertilised, only males hatch out of them.

A queen-bee is a jealous ruler. If a young queen matures, the old queen will ruthlessly slay her rival, unless prevented by the workers. The growing-up of a young queen in the royal cells arouses great excitement in the hive, manifested by an unusually loud humming, the swarming note. Thereupon a large part of the worker-bees leaves the hive and assembles round its exit. The old queen evacuates the field in favour of her rival, and, with her train of attendant workers, flies to the branch of a neighbouring tree and settles upon it, the workers clustering round her in the familiar swarm.

The first task of the young queen, left supreme in the nest, is to kill off the inmates of all the other royal cells. Within a few days after doing so, she makes ready for the

nuptial flight, the one occasion in her life when her sexual impulse secures gratification. Pursued by the drones, she flies to a great height in the air, where only one of her suitors (numbering perhaps as many as ten thousand) succeeds in fertilising her. As previously explained, the successful male then bleeds to death because his penis has broken off in the queen's sexual orifice. (See Fig. 41.) Bearing the token of copulation in her body, the queen returns to the hive. The drone's semen, prevented from

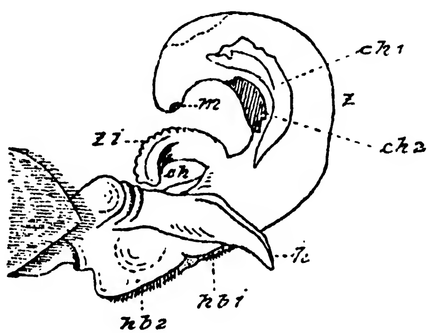


FIG. 41.—A DRONE'S COPULATORY ORGAN FULLY DISPLAYED. (*After* MICHAELIS.)

Z, terminal portion of the penile sac. *m*, orifice of the seminiferous duct. *ch*, *ch1*, *ch2*, chitinous plates. *h*, corneous process. *z1*, azygos nipple-shaped process. *hb1*, *hb2*, equipment of bristles.

flowing out by the fragment of his penis, flows first into the oviduct of the queen and then into the receptaculum seminis where it is stored up. Not until all the sperm is in safe keeping there, does the queen remove the token of copulation with her maxillary palps. Now she is ready to provide her people with new citizens. The store of semen in the receptaculum seminis has to last her for the remaining four or five years of her life. She must be thrifty with it, so whenever an ovum destined to develop into a worker-bee or a queen passes out of the oviduct

into the vagina, no more than a few spermatozoa are squeezed out of the receptaculum seminis. One of these penetrates the ovum through a tiny canal in the latter's enveloping membrane, a canal known as the micropyle, and thus fertilisation is effected. If, on the other hand, a drone-cell is to be peopled, the queen allows no semen to escape when she lays the eggs. The apparatus whereby she is enabled to fertilise the ova or to leave them

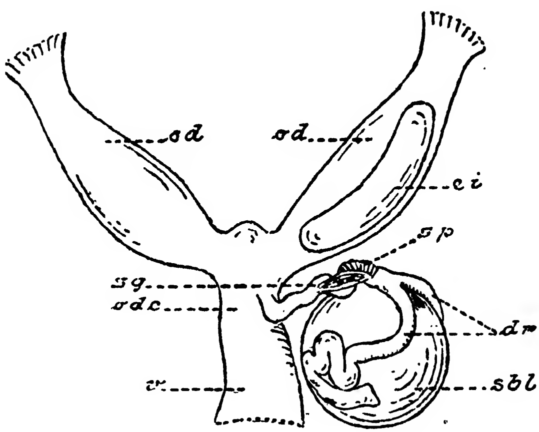


FIG. 42.—RECEPTACULUM SEMINIS OF THE QUEEN-BEE.

od, the paired oviducts. Through the right oviduct there is passing an ovum, *ei*, into the medial and single conjoined part of the oviducts. Into this opens the receptaculum seminis, *sbl*, through the seminal duct, *sg*. *sp*, seminal pump. *dr*, glandular tube. *v*, vagina.

unfertilised at will is extremely ingenious. (See Fig. 42.) At the spot where the two oviducts unite just before the entrance into the vagina, the receptaculum seminis opens through a fine tube, which curves like an S immediately after emerging from the receptaculum. This tube has a muscular wall, so that it can be contracted or expanded as desired. In the wall of the receptaculum itself, there are no muscular fibres. The slit-shaped aperture by which the sigmoid flexure of the tube debouches into the

receptaculum is, in a state of repose, kept firmly closed by the contraction of the muscles. Activity is signalised by muscular relaxation, whereupon the fissure-like opening enlarges, and there is sucked into the tube a minute quantity of semen together with some mucous secretion from the glands in the wall of a glandular tube which forms a diverticulum from the efferent duct of the receptaculum and is attached to the outer part of the wall of the latter. Now the remaining part of the muscle in the seminal duct comes into activity, pressing the semen down into the conjoined oviduct, where an ovum is awaiting it, ready to be fertilised. What influences determine the queen's action in this matter, why it is that she allows semen to escape only when she is depositing an egg in a worker-cell or a royal cell, has not yet been fully explained. It may be that some special tactile or olfactory stimulus proceeds from such cells, and that this leads by reflex action to the discharge of semen in the manner above described.

The queen-bee's seminal pump can get out of order, like any other mechanism, whether designed by nature or by man. The muscles in the wall of the tube may fail to contract after relaxation, with the result that there is a continual outflow of the store of semen until the supply is exhausted. So long as the semen is flowing, all the ova are fertilised, with the result that only worker-bees are produced, whether the ova are deposited in worker-cells or in drone-cells ; but as soon as the store of semen has been used up, only drones can be engendered. Such a failure of function is, however, abnormal. Normally, the apparatus works with mathematical certainty, so that the supply of spermatozoa lasts for four or five years, until the

queen's death is approaching. Then the hive will become "drone-broody", and the community will perish unless a new queen can be raised soon enough by the transference of some of the remaining younger worker-larvæ to royal cells.

Among the ants, no less than among the bees, the importance of males to the community has become inconsiderable, their only function being to fertilise the females during the nuptial flight. To fit them for this task, the males are equipped with powerful wings and vigorously developed sense-organs, whereas their brains are much smaller than those of worker-ants. Among the ants, as among the bees, the workers are imperfectly developed females, upon whom are incumbent all social tasks except that of reproduction. (See Fig. 43.)

The worker-ants are obviously distinguished from the fully-sexed ants by the fact that they have no wings.

Among the ants, polymorphism of the members of the community has been carried much farther than among the bees. In many species of ants, some of the workers are specialised as warriors, for the defence of the community. These soldier-ants have an extremely large head with powerful jaws, which they use as weapons. In the piping times of peace, however, the warriors do not remain idle, but devote themselves to peaceful avocations, using their jaws, not to bite off enemies' heads, but to crack the hard shells of seeds. In certain tropical ants, known as honey-ants (Myrmecocystus mexicanus), a number of the workers have been metamorphosed into living store-rooms. In a sort of cellar provided for the purpose in the ants' nest, they cling with their legs to the roof and are fed with honey by less-specialised workers

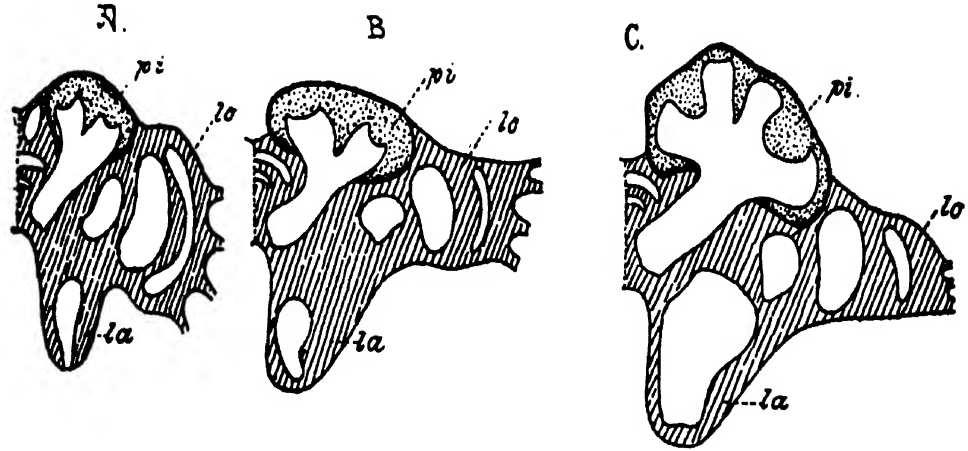


FIG. 43.—RIGHT HALF OF AN ANT'S BRAIN IN FRONTAL SECTION.

A, fully sexed female. B, worker. C, male. *pi*, fungiform body. *lo*, optic lobes. *la*, olfactory lobes. The ganglionic substance is hatched; the fungiform body is dotted; the fibrillary substance is blank. In the worker's brain the ganglionic substance is most strongly developed; in the brain of the male ant, the sensory regions.

until their abdomens are distended into shapeless bladders. The "honey-pots" have lost the power of independent movement. When the community's food-supply from other sources runs short, they have to restore the honey to the worker-ants. The normal workers palpate them until they extrude drops of honey.

The queen-ants are fully-developed females, equipped with powerful wings. At certain times, in the spring, the activity of the anthills in our forests assumes a new form. Winged males and females emerge in vast numbers and fly through the air. In this respect, too, the general periodicity of vital processes is manifest, for almost all the ant communities are simultaneously seized with this nuptial impetus. The males and females rush to and fro round the anthill, climb up the stems of grasses, fall back again, climb up once more—and at length, as if at the word of command, the whole swarm rises into the air. Swarms from other nests rise as well, and at times these flying ants darken the atmosphere round church-towers or other tall buildings, so that it looks as if the neighbouring chimneys must be afire.

Coupling is usually effected in the air, where, generally speaking, the sexes separate. Sometimes, however, a coupling pair fall to the ground before the sexual act is complete, and it is finished on the earth. The male ants perish soon after pairing, whilst the females, as soon as they have been fertilised, set to founding new communities. To begin with, such a female will divest herself of her wings, which have now become superfluous. They break off close to the roots. Then the now wingless female burrows into the soil, making a little closed nest for herself, the germ of the future ant community. There

she waits, in some instances for months, without taking food, until the eggs within her have matured. The reader will naturally be inclined to ask how the ova, which need a rich supply of nutriment, can develop while the queen-ant starves. The answer is simple. With the loss of the wings, the powerful muscles that move them are no longer of importance; they atrophy, and the nutritive substances they contained are turned to account for the general maintenance of bodily nutrition and for promoting the growth of the fertilised ova.

When the time is ripe, the queen lays a small number of eggs which she cares for sedulously until the larvæ hatch out. These, in turn, she mothers, feeding them with the secretion from her own salivary glands until they enter the pupal stage. So soon, however, as the first worker-ants hatch out of the pupa-cases, they take over all the labour requisite for the growing community, and the queen-ant, who has up till now perforce been so industrious, becomes too lazy even to feed herself, and has to be fed by the workers. Gradually she becomes transformed into a mere egg-laying machine. In many species, as for instance in the driver-ants, the queen's abdomen swells so enormously as the ova quickly ripen that it becomes many times larger than before. At first only worker-ants are procreated, but when there is a sufficiency of these most important citizens, fully sexualised ants are also produced.

Sometimes in an anthill several queens will live peacefully side by side, working in common to populate their nests. If a fertilised queen falls to the ground near an anthill, she is immediately seized by the workers of this nest, who tear off her wings, and take her captive. Since

ants will deal in this way, not only with queens of their own species, but also with queens belonging to extraneous species, mixed populations arise. For instance, in Germany such mixed communities often consist of the red forest-ant, Formica rufa, and an allied species, the brownish-black ant, Formica fusca. Since Formica rufa is extremely pugnacious, whereas Formica fusca is comparatively timid and weak, it used to be believed that the specimens of Formica fusca in the joint nest were the slaves of the specimens of Formica rufa. It no doubt happens from time to time that the soldier-ants of the Formica rufa species will invade a Formica fusca nest, carry off the larvæ and pupæ of the latter, and bring them up in their own nest. As a rule, however, the relationship is a more peaceful one, so to say, that of adoption. If a fertilised rufa queen falls to earth near a fusca nest which has lost its own queen, the rufa queen will be pulled into the nest to lay her eggs there. It is true that the fusca worker-ant can still lay eggs and that out of these eggs there will hatch, not only males, but also worker-ants—for among the ants the non-fertilisation of an ovum does not, as among the bees, necessarily signify that the offspring will be a male. This state of affairs among bees depends upon the peculiar nature of the chromatin-contents of their reproductive cells. In many animals which reproduce themselves parthenogenetically, we find, even, that out of unfertilised ova there develop exclusively females, perhaps for many generations in succession. However, the laying activities of the fusca workers are not sufficient to ensure the perpetuation of the species. By degrees the fusca citizens die out, being replaced, in continually increasing numbers, by the developing rufa

larvæ, so that what was originally a fusca State is gradually transformed into an exclusively rufa State.

The termites, often called " white ants " (although phylogenetically they have nothing to do with the ants but are closely akin to cockroaches), do not properly belong to this chapter inasmuch as among them the males are not oppressed or enslaved. The king-termite and the queen-termite lead a peaceful conjugal life, and the other citizens of the community, the worker-termites, are of both sexes, rudimentary males and rudimentary females. In many respects, however, their mode of life so closely resembles that of the ants that it may as well be considered here.

Polymorphism is even more strongly developed among termites than among ants, the division of labour being yet more highly specialised in the nests of the former ; and, in accordance with these differences of function, the various types of individual exhibit great structural contrasts. As with the ants, fully sexed termites, whether male or female, are equipped with wings. As with the ants, the male and female termites swarm outside the nest—but it is not a nuptial flight, they do not pair at this time—speedily returning to earth and discarding their wings by the rupture of a transverse suture close to the roots. At this period of their development, the males and the females are both immature, so that the flight is a betrothal flight. As with many savage races, the young are bound together in marriage before they can fulfil the purposes of marriage, and a considerable time has still to elapse before the termites' reproductive glands are sufficiently developed for consummation. None the less, the betrothed couples are faithful to one

another till death them doth part. Months after the betrothal, copulation at length occurs. Then the king and the queen set about founding a nest, and subsequently, when their young have grown up to be male or female worker-termites or soldier-termites, the father and the mother still cohabit in the royal chamber, surrounded by a court of worker-termites, which pay them loyal service in the way of cleaning them up and licking them down. They also feed their royal master and mistress, while at other times they are busied in the removal of the queen's eggs, which are laid to the tune of about eighty thousand a day. The king and the queen have the additional safeguard of being surrounded by an escort of soldiers. The entrance to the royal chamber is so narrow and so low that their majesties can never leave it. In view of their amazing fertility and their long lives (a queen-termite can live to the age of fifteen), the original supply of semen must obviously be insufficient, and the male must again from time to time have sexual intercourse with his spouse.

An important difference between ants and termites consists of this, that among the termites the workers and the soldiers are not exclusively females that have failed to achieve a full sexual development, but juvenile forms of both sexes which have not yet attained sexual maturity. Like the cockroaches, termites have no larval and pupal stages, hatching out of the eggs in the imago form, though very small, to grow by successive moults. The king and the queen experience five moults before becoming sexually mature; but the workers and the soldiers, some of them having male rudiments and others female rudiments, pass through only four moults.

The capacity for asexual reproduction by fission or by budding is the most primitive quality of an organism. When an animal species which has attained to sexual reproduction through the fertilisation of ova by spermatozoa continues, in addition, to reproduce by fission or by budding, it has merely retained a capacity which its ancestors primarily possessed. When, however, a sexualised creature renounces sexual intercourse, and lays eggs which develop parthenogenetically without fertilisation, this denotes a new acquirement which can only be explained as an adaptation to changed conditions of life. Inasmuch as both ova and spermatozoa have in their respective nuclei all the heredity factors requisite for a complete organism, they remain theoretically capable of producing, each of them, a new living creature without fusion—though naturally a creature thus engendered would not inherit the conjoined strains of a father and a mother, but only the hereditary trends of a single parent. An essential precondition of such parthenogenetic development of an ovum would be that the stimulus normally provided through penetration by the head of a spermatozoon should be furnished to the ovum by some other determinant. Experiment has shown that the stimulus normally provided by the head of a spermatozoon can be artificially supplied in some other way. If, for instance, the ova of certain animals, such as frogs, which never under natural conditions develop beyond a unicellular stage without fertilisation, are pricked with a finely pointed glass needle, the ovum promptly divides and subdivides just as though fertilisation had occurred; and it has even proved possible, under suitable conditions, to grow such ova into viable

adults. Nevertheless, for purely mechanical reasons, this capacity for independent development is restricted to the ova, which, in contrast to the spermatozoa, have retained all the characters proper to the cell. Spermatozoa, conversely, in adaptation to their specialised task, which demands a very high mobility, have lost almost the whole of their protoplasmic body. None the less, the heredity factors for constructing a new individual still exist in them. Could a spermatozoon be equipped with a new protoplasmic body, it would be theoretically capable of developing into a viable individual without having united with an ovum.

A critical reader will perhaps be inclined at this point to accuse the author of entering the domain of futile speculation. How, he will ask, could a spermatozoon be re-equipped with something that has been lost millions upon millions of years ago in the course of phylogenetic development? Well, biologists have actually been able to perform this apparent impossibility. Nay, more, the experiment is not so difficult as uninstructed persons might suppose. We can perform operations, not only upon the human body, but also upon the tiny ova of sea-urchins and starfish. Such operations are done under the microscope. With a little practice, the experimental biologist is able to deprive such an ovum of its nucleus. If a denucleated ovum be now introduced into a medium filled with the spermatozoa of a sea-urchin or a starfish (as the case may be) then a spermatozoon will penetrate the ovum just as if the latter possessed a nucleus. In a word, an act of fertilisation takes place, with the production of a fertilised ovum whose nucleus now consists only of elements derived from the head of a spermatozoon.

This ovum, therefore, has within it none but paternal heredity factors. Still, we have restored to the spermatozoon the cell-body its ancestors lost long ages ago, and have therewith endowed it with the nutritive material requisite for further development. In very truth such an ovum-spermatozoon will divide and begin to develop into a larva. By hybridising various species of starfish whose larval forms are conspicuously different, it has been possible to show that larvæ grown from ova which have been denucleated and then fertilised by spermatozoa are equipped with exclusively paternal qualities. Here you have a new proof that the chromatin of the nucleus, and nothing else, is the carrier of the heredity factors. What man has here been able to achieve artificially by mechanical or chemical stimuli, inducing ova which normally require the stimulus of fertilisation before dividing to divide in response to other stimuli, has been achieved by nature in a number of widely differing animals as an adaptation to peculiar conditions of life. Parthenogenetic development occurs chiefly in animals living under unfavourable conditions of existence. It provides for a rapid multiplication of the species. Since, side by side with parthenogenesis, sexual reproduction has been retained, asexual and sexual multiplication replacing one another at more or less regular intervals, there arises what is known as alternation of generations, or heterogonia.

In many animals, parthenogenesis is no more than an occasional affair, occurring, so to say, experimentally. This happens, for instance, in the case of the silkworm, Bombyx mori, unfertilised ova of the silkworm moth sometimes beginning to divide. In most cases, however,

the vital energy of these parthenogenetically developing silkworms' eggs speedily subsides. Only two or three divisions take place, and the embryos perish at an early stage. Some few, however, develop into normal caterpillars which form chrysalids, and, out of the cocoons, fully grown and vigorous silkworm moths emerge. The eggs of the silkworm require, in fact, only a very slight stimulus, which need not necessarily be supplied by a spermatozoon, to set them a-growing. If they are rubbed gently between the folds of a soft cloth, or if they are dipped for a moment in a faintly acid solution, they promptly start growing, and out of such ova, artificially aroused to a parthenogenetic development, fully adult silkworm moths have been grown.

As I have already mentioned, certain Indian grasshoppers, when transplanted to new climatic conditions, suddenly begin to reproduce themselves parthenogenetically. And I related how, in such cases, the procreation of males and therewith sexual reproduction passes into the background.

There is a fresh-water crustacean of somewhat primitive type, Triops cancriformis, whose shape reminds us of the long extinct trilobites of the Silurian seas. A fully developed triops is little more than an inch long. For years the creature seems to be non-existent. Then, when the river is in flood, for instance in the neighbourhood of Berlin, vast numbers of triops will appear in the flooded fields. Since the common people found the sudden appearance of these strange animals inexplicable, a superstition arose to the effect that they were rained down from heaven. When the meadows dry once more, triops disappears, not to be seen again until, after the

lapse of several seasons, a freshet awakens it to new life. Almost all the specimens of triops we can catch are females. These females lay unfertilised eggs. Buried in the mud, the ova preserve their developmental possibilities for as long as ten years, waiting for favourable conditions of existence, which come for this creature when the meadows are flooded. That explains the sudden reappearance of so large a population. In Germany, male specimens of Triops cancriformis are extremely rare. In Hungary and Russia, on the other hand, males are common enough, and reproduction is chiefly effected by fertilised eggs. Another instance of the way in which the mode of reproduction can be affected by climatic influences !

A much smaller crustacean has attained widespread popularity because everyone who keeps an aquarium buys quantities of it as food for his fishes. The scientific name of this creature is Daphnia pulex, its vernacular name being water-flea. In Germany, water-fleas abound in almost every pond or puddle. During spring and summer females only are to be seen ; these lay unfertilised eggs, producing more females, such a parthenogenetic development occurring in lively fashion for many generations. The development of the ova takes place within the maternal body, in a proportionally large cavity set apart for the purpose between the cuirass and the soft tissues of the back. There is no larval stage. The young daphniæ do not leave this shelter until they are typical crustaceans, although they have not yet, of course, attained their full size. In the autumn, when colder weather comes, there suddenly grow out of part of the eggs still smaller daphniæ, which are of the male

sex and which vigorously perform their masculine function. Thus the numerous parthenogenetic generations are followed, as the close of the annual rhythm, by a sexual generation. The fertilised winter ova likewise remain for a time, though a brief one, within the maternal "uterus", where, with the aid of a secretion from special glands, they are invested with a firm chitinous shell. These winter ova are also distinguished by possessing a great abundance of yolk. Like the crayfish, daphnia moults from time to time, and when the autumn moult takes place the winter ova are discarded with a part of the cast-off shell which has become peculiarly thickened and is known as the ephippium. Protected by the ephippium and by their chitinous shell, the winter eggs pass safely through the cold season; and when, in spring, new life is everywhere awakening, these winter ova develop into a new generation of females. Thus in the daphniadæ there has already arisen an alternation of generations. When climatic conditions are most favourable, daphnia has no use for males, multiplying abundantly by parthenogenesis; but when the cold season begins, sexual reproduction comes to the front once more, with its provision for a crossing of stocks, for amphimixis.

Still more readily can anyone who has access to a garden watch the rhythmic succession of parthenogenetic and sexual reproduction in the plant-lice or aphides. As every garden-lover knows, this "blight" particularly affects roses. As soon as the roses begin to unfold their buds, the rose-aphis, Macrosiphum rosæ, almost invariably makes its appearance upon the scene. At first these pests, which are of a green or brown colour, and thrust

their probosces deep into the soft tissues of the plant on which they establish themselves, appear only as isolated specimens, settling with especial favour upon the young shoots and buds. The first aphides of the season have no wings. They are exclusively females, but atrophic females, not possessing a receptaculum seminis to hold the male sperm or a cement gland to make the ova adhere. Even if there were males among them, they would be unfitted for copulation. After the long winter rest, these aphides, these females, have hatched out of fertilised eggs laid in the previous autumn, and, in the course of ten days, making four moults, develop into sexually mature insects. Very soon every one of the females is surrounded by from sixty to a hundred little aphides, which likewise grow up in the course of ten days. Such young, too, are exclusively females, developing out of unfertilised ova in the interior of the maternal body. In a word, the first aphides are parthenogenetic females which bring living young into the world. Thanks to the fact that males are not needed at this stage, to the fact that all the young are females, and that these new females are capable after ten days' growth of bringing fresh young into the world, and inasmuch as the process continues for nine generations, the reproduction of aphides is extraordinarily rapid. Were it not that a great many of them fall victims to the attacks of human beings and other enemies, a single female aphis could, theoretically, by the end of the summer, produce offspring numbering many trillions. Happily for all flower-lovers, a natural limit is imposed upon this fertility. The reproductive capacity of the parthenogenetic female, who was able in the first generation to bring forth about

one hundred young, declines from generation to generation, so that in the last parthenogenetic generation the mother gives birth to only about ten or fifteen children.

Wingless aphides are inert and slothful creatures disinclined to stir from the spot at which each of them has thrust its proboscis into the plant. Of what use, then, can this extraordinary fertility be to plant-lice? They have, so far as we have yet seen, no means of diffusing themselves. Their enormous multiplication with the consequent terrible loss of sap by the rose-tree on which they are parasitic, will kill the latter after a few generations of the aphides have grown, and therewith the plant-lice which have destroyed it will likewise perish. Nature, however, has found an expedient to provide, not only for the multiplication, but also for the diffusion of the species. When for two or three successive generations none but wingless females have been born, some of the young prove to be equipped with well-formed wing-rudiments, and these specimens, after four moults, have efficient wings. From the sexual point of view they are still no more than imperfect females, but their wings enable them to fly to other rose-trees, there to continue their devastating parthenogenetic activities. At length, in the tenth generation, wingless females which are fully developed sexually make their appearance. These have a receptaculum seminis and a cement gland. Simultaneously, winged males are formed. We see here, once more, males whose power of flight is developed to enable them to seek out the inert females. It is not long before there will be noticed on the back of every fully developed female a winged male in the act of copulation.

The females thus fertilised are not, like the females

Karl Stülcken

FIG. 44.—DRAGON-FLIES PAIRING

Paul Unger

FIG. 45.—MALE STICKLEBACK DRIVING HIS MATE INTO NEST EXCAVATED IN THE SAND

Paul Unger

FIG. 46.—A MINNOW IN THE ACT OF DEPOSITING HER OVA, THROUGH A LAYING-TUBE, IN THE RESPIRATORY ORIFICE OF A POND-MUSSEL

of the first summer generation, viviparous but oviparous. They lay " winter-eggs " in fissures in the bark and in the neighbourhood of the winter-buds. The eggs are protected against the rigours of the season by strong shells, and from them, next spring, there will hatch out a new generation of parthenogenetic females.

Thus, in the rose-aphis, we have an alternation of generations manifesting only one alternation in the course of a single year. The nine parthenogenetic generations are followed, when the chilly season begins, by a sexual generation. This rhythm can be modified. If plant-lice live on plants kept in a hothouse, the appearance of fully sexed specimens will remain in abeyance for years. The aphides continue for an indefinite period to reproduce their kind parthenogenetically. In certain other species of aphis, the cycle of the generations is different. A parthenogenetic generation may be immediately followed by a sexual generation; or there may be two or three parthenogenetic generations before the sexual generation appears. It can always be shown that the type of the reproductive cycle is an adaptation to the peculiar conditions of existence for the species concerned; and that the cycle is modified when the conditions of existence change.

A like alternation of generations, a similar cycle in which a period of asexual or parthenogenetic reproduction is replaced by the appearance of males and by sexual reproduction, is met with in certain species belonging to almost all the classes of the animal kingdom, vertebrates alone excepted. An alternation of generations is especially common in parasites. The evolutionary process which first led to the appearance of the male and female

sexes with their differing reproductive cells, with their ova designed for fertilisation by spermatozoa, has not everywhere persisted in its ascending course. The advantages of sexual reproduction may, when the conditions of life are modified, be outweighed by the disadvantages attendant upon the fact that only the females of a species can bring forth young, and that in procreation by separate sexes the males have to seek out and copulate with the females. When this happens, nature renounces amphimixis for a longer or shorter period. The females become independent; their ova acquire the capacity of parthenogenetic development; the male sex passes more and more into the background, so that males are only produced at long intervals; and, in extreme cases, males may completely disappear. However, the alternation of generations, and still more the complete suppression of males, are exceptional adaptations to peculiar conditions of existence. In the majority of organisms the sexual impulse and love, coitus and fertilisation, retain their outstanding importance, the whole life of the species turning upon the success of the males in searching for and finding the females, in copulating with them and fertilising them—so that each new generation is equipped with a new mingling of heredity factors.

CHAPTER SEVEN

LURES AND STIMULI

TO seek and to find, to clasp in a firm embrace and to effect fertilisation—herein lies the quintessence of the sexual impulse. Amazingly diversified are the ways and means which have been devised in the organic world to favour this searching out and mutual discovery of the sexes. A learned man once declared that, with the solitary exception of the wheel and axle, there was no mechanical device invented by human beings which was not to be found in one form or another as an achievement of unreasoning nature. Even in the art of love, which especially among orientals has been raised to the level of a science, man has discovered nothing for which a precedent did not exist in the animal kingdom. The various apparatus for the intensification of sexual stimuli, the allurements put forth by the females, the methods and instruments of masculine wooing, the elaboration of the sense organs, the most intricate developments of the reproductive organs, and the secondary sexual characters of this species and of that, are so multifarious that their mere enumeration would fill several volumes. In this work, which deals with no more than the alphabet of love, the author must content himself with a concise survey of the principal institutions which have been adopted to promote a union of the sexes.

Since, in general, the active rôle is assigned to males,

whose business it is to seek out the comparatively inert and passive females, we usually find that the males of any species are equipped with better and more vigorous locomotive organs and with more highly developed sense organs. We have already noticed this in the case of certain insects, for example in many butterflies and moths, in which the wings of the females are rudimentary structures so that the insects are unable to fly and have comparatively little power of locomotion, whereas the males have their wings fully grown. But there are a good many thick-bodied nocturnal moths in which the females, although they still possess fully-grown wings, seem to have lost the locomotive instinct. After they have emerged from the pupa-case and have unfolded their wings, they scarcely stir from the spot, at most crawling a little way up the stem of the tree on which they have hatched out, waiting inertly for the visit of a male. The males of the same species are restless creatures. To seek out their wives they need, not only the capacity for flight, but also keen sense organs to disclose to them where their mates are awaiting them.

Consider, for instance, the antennæ of certain moths. In the males the sense organs are equipped with long lateral ramifications or feathers, which enable the creatures to detect the existence of a female several miles away. The antennæ are extremely delicate olfactory organs, responding to stimuli proceeding from a female. Each feathery ramification has on it numerous pits or fossæ, bearing olfactory cones. The antennæ are always directed upwind. The females of the same species have, on the posterior end of the abdomen, glands which secrete an odoriferous substance—odourless indeed to us,

but perceptible by the male moth at a distance of several miles. Weismann records an experiment in which, at Freiburg, in his laboratory which was situated in the middle of the town, he confined a female Smerinthus ocellata in a wire-gauze cage, placing this cage by night near an open window. That same night, forty-two males made their appearance in the laboratory. We have satisfactory evidence that in such cases the secretions of the female's odoriferous glands do in fact furnish the Ariadne's clue by which the male is guided to the nuptial spot, for when the secretion of these glands is soaked up by a fragment of blotting-paper, lustful males will crowd round the lure.

In other insects, such as beetles, flies, etc., we find similar apparatus, which naturally vary much in different species. They are always most fully evolved among those organisms in which the females have become slothful, sluggish members of their sex, whereas the males, as a compensation, must have developed an exceptionally keen sense of smell. We shall learn in due course that among the higher animals, no less, the sense of smell often plays a considerable part in the discovery of the females by the males; but in mammals the influence of odoriferous stimuli is even more important in respect of promoting the vigour of the sexual impulse. This applies especially to human beings.

We learned that on the nuptial flight a queen-bee soars high into the air, the drones following her eagerly, and the successful competitor having intercourse with her on the wing. That the males may keep the female in sight, they are equipped with very large compound eyes, at least twice as large as the eyes of the queen-bee, so that their

field of vision is enormously expanded. There are many other insects in which a more effective development of the organs of vision in the male is of great importance to the sexual life.

On the seashore, between high-water mark and low, we can see crawling slowly over the seaweed a worm-like creature with short, stumpy legs. This is the degenerate female form of a fly, clunio by name, which has become little more than a breeding machine. The males of the same species are normal-looking flies with powerful wings and sharp eyes. They fly briskly hither and thither along the strand. When a male catches sight of such a misshapen female (who, degenerate though she be must obviously still exert a mysterious lure), he picks her up, and copulates with her in the air. As soon as he has had his will of her, as soon as impregnation has been provided for, he flies back with her and deposits her on the spot whence he had carried her off.

A very remarkable adaptation to a sexual function is manifested by the eyes of the male day-fly or ephemeris. Male ephemerides' eyes are not merely, like those of drones, much larger than those of the females of the species, but are differently constructed from the visual organs of female day-flies and equipped with a different function. In extreme instances, the eyes may be doubled. Then, whereas the lateral eyes have an anatomical structure identical with that of the eye of the female ephemeris, the centrally situated eyes exhibit a marked prolongation of their facets. These central or frontal eyes form a structure looking like a turban crowning the head, and are therefore sometimes spoken of as "turban eyes". They are much less pigmented than the lateral eyes, and would

seem to be specially adapted for vision in the twilight and for the perception of rapid movement.

There can be few of my readers but must have watched, on warm summer evenings, the air-dance of ephemerides above ponds and damp meadows. These swarms of dancing flies are exclusively composed of males, for the females are hidden in the neighbouring grass. Suddenly, however, a female will rise into the air to a considerable height above the dancing males. Instantly a number of the males will break away from the swarm to pursue this female, and the swiftest of the pursuers will effect intercourse with her.

Although the turban eyes of the day-fly are well fitted to perceive an object moving quickly in the twilight, they do not achieve distinct vision. Other insects which may chance to flit above a swarm of dancing male ephemerides will be pursued by some of them, and not until the hunters get close to the quarry will they recognise their mistake and rejoin the swarm.

In the depths of the ocean, where (since no light-rays can penetrate more than about fifteen hundred feet of sea-water) eternal darkness prevails, we nevertheless find animals with well-developed eyes. This is remarkable, seeing that in cave-dwellers (for instance, the fauna of the Mammoth Cave in Kentucky) the eyes have atrophied. A typical example is the cave-olm (proteus), an amphibian inhabiting the subterranean waters of Carniola, Dalmatia, and Carinthia, whose eyes are completely covered with skin. But the eyed inhabitants of the deep sea have organs of vision for the perception of " artificial illuminants " which are found in these regions of everlasting night. The lovely phenomenon of phosphorescence,

which we see even in our northern waters but which is much more brilliant in the Mediterranean, is mainly dependent upon small ciliated infusoria, above all upon Noctiluca miliaris and Leptodiscus medusoides, which on calm, warm evenings rise in milliards to the surface and make the sea (whenever the water is stirred) luminous over great areas. The waves in these phosphorescent waters, have a lovely greenish sheen as they break. But, infusoria apart, many of the higher metazoa are luminiferous. Cuttle-fish, and various crustaceans and fishes of the deep sea, have light-organs as specific characters which play an important part in promoting the mutual approach of the sexes.

In the skin of deep-sea fishes we often find numerous spherical glandular organs, arranged in patterns which vary from species to species, and radiating light, now of one colour and now of another, so that the members of the same species can recognise one another from afar. Inasmuch as the patterns displayed by these light-organs are also different in males and females of the same species, we are doubtless right in conjecturing that such " illuminated signs " serve as sexual distinctions—just as do the " lanterns " of fire-flies.

In their simplest form, these light-organs (which in former days were erroneously regarded as eyes) consist of spherical glandular sacs filled with an illuminating material and imbedded in the skin. On their deeper aspect, the glandular sacs are covered with a pigmentary coat, but are free from pigment on the surface. The epithelial cells that cover them are transparent, and are so arranged as to form a lens over each gland. On the inner surface of the pigmentary coat the cells have been modi-

fied into an iridescent membrane like the tapetum lucidum in the choroid of cats. This forms a sort of reflector which projects the light generated by the light-glands through the lens for a considerable distance into the water. In many of these deep-sea creatures there are attached to the light-organs muscles with whose aid they can be voluntarily shuttered-off, as it were, by flaps of skin (like eyelids). Recent investigations in a number of luminous animals have shown that the light is not necessarily produced by the animal itself for, in many cases at any rate, it is the outcome of a peculiar kind of friendly alliance, of what is known as symbiosis. Just as in Hydra viridis the green colour of the polyp depends upon the presence, in the body-cells of the hydra, of living algæ which are transmitted in the ovum out of which the young hydra was formed, so in the interior of the luminous glands of deep-sea fishes it can be shown that luminous bacteria exist. We do not know, as yet, whether this explanation applies to all luminous organs.

A study of two different kinds of fire-fly which are widely diffused in northern Africa and southern Europe, namely the small fire-fly, Phausis splendidula, and the large fire-fly, Lampyris noctiluca, has plainly shown that such light-organs subserve the purposes of reproduction. Whereas the males of these species are beetles (not really flies) equipped with well-formed wings, the wings of the females are atrophic. The females are the well-known " glow-worms " which, on warm nights in early summer, can be seen in the grass or in bushes, radiating their clear greenish light. In the females of the large fire-fly, Lampyris noctiluca, the light is emitted by two transverse bands on the lower side of the sixth and seventh abdominal

segments. In addition, there are to be found on the abdominal aspect of the creature several spots of light, varying in number. The chitinous investment has become thin and transparent where it covers the light-organ, so that the light shines through unhindered as through a window. The males have only the two light-plates upon the sixth and seventh abdominal segments. The light-organs of fire-flies consist of fatty tissue well supplied with fine nerve-fibrils and richly surrounded with air-channels providing for an ample supply of oxygen. Whilst during the day the females are humped upon the ground in a normal attitude with their legs downwards, after nightfall, when the males begin to soar through the air as tiny luminous points, the females turn on their backs, exposing their luminous bellies, which are thrust upward to show their partners the way. Besides, whilst the females are much more strongly luminous than the males, the males greatly excel the females in the acuity of their visual organs. Each lateral eye of a male fire-fly has about two thousand five hundred facets, whereas the eyes of the females contain only about three hundred facets.

Now let us return to consider the olfactory sense in relation to the sexual life. Not only do the females of many species emit odours which attract the males and tell them where they are wanted; but in both sexes scents can serve as means of sexual wooing and as stimuli which greatly intensify the sexual impulse, and which, when the odour of the male impinges upon the female's olfactory organs, make her more inclined for pairing. The odoriferous apparatus of many male butterflies would appear to exercise a strongly exciting influence

upon the females of the same species. Such odoriferous organs assume various forms and may present themselves on different parts of the body. In a great many butterflies we find upon the wings porous scent-scales, connected with an underlying glandular cell which pours out a strong-smelling secretion. Sometimes these odoriferous scales are distributed all over the surface of the wings, interspersed among the ordinary wing-scales ; but in other species they are condensed into special odoriferous areas or patches. Occasionally the secretion of the odoriferous glands collects in special containers at the stalk of the scale, whence it spreads into the spongy chitinous tissue with which the scale is filled to exude through numerous pores in the wall of the scale on to the surface, where it speedily dries up. In a good many butterflies, these odoriferous scales are normally hidden away in deep pouches, which only open at times of sexual excitement in order to emit their scent. We find this for instance in certain night-moths (noctuids); and in an extremely characteristic form in swallow-tail butterflies, in which the hair-shaped scent-scales are situated in a deep pocket that lies along the inner border of the posterior wing. Yet other butterflies and moths have their odoriferous patches in depressions near the anus, the little bush of scent-diffusing scales being vigorously everted as soon as the male approaches a female. These arrangements prevent a needless waste of the secretion. In many cases our own olfactory organs are not keen enough to perceive the odour thus emitted, but sometimes we notice an agreeable scent of vanilla or of wild strawberry, or (in the case of the death's-head moth) a penetrating smell of musk.

There are many other animals in which this smell of musk serves as a sexual lure, becoming especially noticeable at the rutting season. Crocodiles, for instance, can be smelt long before they can be seen. In these reptiles, both sexes have musk-glands, arranged in two pairs, the duct of one pair of the glands opening into the cloaca. It is probable that the pappy and strong-smelling secretion of the cloacal glands serves, not only to promote sexual appetite, but also to lubricate the walls of the cloaca, whereas the other pair of glands, whose duct opens upon the under side of the lower jaw close to the angle of the mouth, have manifestly none but a sexual function. They serve to intensify the sexual impulse in members of the opposite sex. In the Sudan and other parts of Africa the musk-glands of the crocodile are greatly esteemed by native women, who smear their hair with them when they wish to make themselves attractive to their husbands, and do not grudge to pay for such a treasure with as much as two head of cattle. Nor does civilised man despise the use of this lure, musk being an important ingredient of a great many perfumes. It has a clinging odour, which persists when ethereal oils have long since evaporated. Patchouli, the scent prepared from an oriental plant which has a cloying odour not unlike that of musk, was until recently much favoured by ladies of the demi-monde because of its presumed stimulating effect upon men.

Musk-glands are also found in various mammals. The ducts of these glands usually open close to the sexual orifice or near the anus. The males of the musk-deer, Moschus moschiferus, a small and graceful deer about twenty inches high at the shoulder, an inhabitant of

eastern Asia, give off at the breeding season so penetrating an odour of musk that even we humans, with our inefficient noses, can smell them two or three miles away. Since the market price of a musk-pod ranges, according to quality, from thirty shillings upwards, the musk-deer is vigorously hunted with fire-arms, and snares are set for it. The annual export of musk from China is worth about £100,000. All the same, pure musk is a rarity, for the Chinese adulterate it with various other substances.

The musk-pod, a small, pear-shaped bag a little over two inches in length, opens on the mid-line of the belly just before the preputial orifice. The walls are thickly beset with glands which secrete a pappy, reddish-brown substance that does not develop the typical odour of musk until it has been strongly diluted or until it dries. The male musk-deer, in whom alone these organs are present, can squeeze out the secretion with the aid of muscles surrounding the pod. The fact that the female musk-deer has no such glands is a plain indication that musk is a sexual stimulant whereby the male excites the female.

Bats have peculiar love-calls with which the sexes are wont to attract one another; but, apart from this, in many species of bats the males have a gland which pours into a pouch that opens just behind the root of the penis a secretion having a strong odour of musk. This secretion, whose smell develops as it dries by evaporation, seems to predispose the female to sexual intercourse.

In many respects, bats are remarkable for the peculiarities of their amatory life. Whereas most animals, and especially the males, are a prey to violent jealousy in the breeding season, the males being apt to engage in violent combats for the possession of a female, it is otherwise

among bats. These creatures, which in general are quarrelsome and are continually biting one another, become examples of forebearance and kindliness as soon as love stirs within them. Several males will look on quietly while another is copulating with a female. They wait patiently until their rival has finished his embrace, and then take turns to follow him. We can literally speak of an " embrace " as far as bats are concerned, for they reciprocally envelop one another in their wing-membranes. Copulation occurs in autumn. The store of semen in the uterus, derived from several males, remains there unutilised for a considerable time, since the ova do not ripen until the following spring, and till then the seed must be preserved in the female sexual passage. To prevent profluvium seminis (an outflow of the semen), the cervical canal of the uterus is hermetically sealed by a plug consisting of secretions from the mucous membrane mixed with white blood-corpuscles and cast-off epithelial cells ; or in some cases there is a vigorous cell-proliferation to form the plug, which may hang down into the vagina as a thin cord. Thus bottled up, the spermatozoa live and retain their fertilising capacity for six months, until, when spring comes round, the ova are discharged into the uterus. As soon as fertilisation and the implantation of the fertilised ova have taken place, the plug is expelled from the cervix.

When copulation is over, the sexes separate, the females withdrawing in a herd to seek a retreat in a hollow tree or in a cave, while the males return to their solitary bachelor lives, quarrelling in the old fashion whenever they meet one another.

Castor, a secretion of the preputial follicles of the

beaver, and a similar secretion of the preputial follicles of the musk-rat—secretions which are thus poured directly into the sheath of the male penetrative organ, more profusely in the breeding season—are likewise sexual lures and promote sexual excitement in the females. It is easy to observe how, at pairing time, beavers discharge the contents of these glands in particular places, and how the odour that is diffused from such spots quickly attracts other members of the species.

In birds, as a rule, smell plays a subordinate part in the relations between the sexes. It is certain, however, that the strong musky odour which, in the breeding season, is given off by the musk-drake, Cairina moschata, and which is probably secreted by the rump-gland, acts as a sexual stimulus.

Even in civilised human beings, whose olfactory sense has to a considerable extent regressed, there is demonstrable an anatomical and physiological connection between the nose and the genital organs, the excitability of the reproductive organs being in both sexes accompanied by changes in the activity of the nasal mucous membrane. Perhaps this accounts for the fact that among many savages (whose olfactory sense is much keener than ours), but also among certain highly civilised races, the kiss, which is one of the most important contrectative demonstrations on the part of Europeans, is replaced by the practice of rubbing noses.

The arm-pits of human beings and some of the higher apes are organs which promote sexual excitement through olfactory channels. The secretion of the sweat-glands with which the axillary skin is so richly equipped, although its smell is apt to be offensive at ordinary times,

intensifies sexual appetite when this is already present. The specific quality of the secretion of the axillary sweat-glands does not appear until puberty. Simultaneously, hair begins to sprout in the arm-pits, and this hair, like the odoriferous scales of butterflies, provides a locale on which the scented secretion can accrete as it dries.

In both sexes, the bodily odour becomes much more marked during the rutting season. Consider, for instance, the penetrating stench of the billy-goat. The smell that emanates from the genital organs of female animals on heat is also alluring and exciting to the males of the same species. When, for example, a bitch goes on heat, all the dogs of the neighbourhood assemble, and will unfailingly follow her trail. We notice, too, that at such times, when the love passion reaches its climax, the combativeness of dogs is apt to be much less marked than usual. I was able to watch this very well in my own collie dog Lux and my little terrier bitch Peti. When Peti first went on heat, and was still in a mood to drive off all wooers, Lux, followed by Peti, furiously attacked every strange cur which entered the garden and began to pay court to the lady. But when matters had gone so far that Peti became inclined for intercourse, although Lux continued to make a show of hostility, he put up no more than a sham fight, being content, after a while, to leave the intruder at peace. When a dog and a bitch are locked together after the act of intercourse, they will often be surrounded by a circle of languishing dogs, but these seldom show any inclination to use their teeth.

Both dog-foxes and vixens have rutting-glands on the upper side of the brush, near the root. At the pairing season, there exudes from these an agreeable odour,

reminding us of the scent of fresh iris root. Many of the ungulata, too, have rutting-glands in various parts of the body—of which the rutting-figs of chamois are typical examples. These rutting-figs are found on the upper surface of the head, immediately behind the horns, and, at the rutting-season pour forth a substance which has (to us) a rank smell, like that of rams and goats.

In human beings, no less than in the lower animals, we find that odours repulsive at ordinary times are sexually exciting at suitable seasons. Many men find the smell of a menstruating woman sexually stimulating, and many women are similarly excited by the odour of a sweating man. A typical rutting-gland, met with both in antelopes and stags, is shown in our illustration of an Abyssinian klipspringer (plate facing p. 160), Oreotragus oreotragus, of which there is now a pair in the zoological gardens at Frankfort-on-the-Main. The large gland is clearly shown in the picture beneath the inner canthus of the eye. It pours out a buttery aromatic secretion, having the odour of fruit-esters. These graceful little creatures, which stand about six hands high at the shoulder, inhabit the lonely and rocky regions of the African mountains, at an altitude ranging up to eight thousand feet. They are timid, unsociable animals, but the strong odour which emanates from the before-mentioned gland at the pairing season helps the members of the two sexes to find one another.

The behaviour of a stallion shows plainly enough how exciting to him is the smell emitted by the genital organs of a mare on heat. As soon as the stallion has been brought to the mare and has nuzzled her thoroughly, he throws up his head and draws back the upper lip in a

characteristic way. Very soon after this, he will cover the mare. Bulls, rams, and billy-goats, behave in exactly the same way.

Let me return once more to the charming love-play of the crested salamander. After the male has pursued the female for a long time and has been showing off all his beauties to her, he swims in front of the lady of his choice, lashes the water with his tail, and slaps his wife's side with the same organ. Thereby the odours exuding from numerous glands whose ducts open upon the posterior fold of his cloaca are wafted towards the female. This sport may be continued for several days, until at length the female shows her readiness for active co-operation by following the male as he swims and pressing her nose against the cloacal aperture of her husband. What follows has been described on pp. 153–154.

The ear, no less than the nose, is in countless animals pressed into the service of the sexual life, and (chiefly in the males) various sound-producing apparatus have been devised for this purpose. In human beings, however, the auditory function seems to have little concern with the sexual life, although a pleasant voice is certainly an added charm. We read, for instance, in *King Lear*: "Her voice was ever soft, gentle, and low—and excellent thing in woman."

Sound-producing apparatus have been greatly developed in many insects, as for instance in grasshoppers. In these cases it is not from the mouth that the notes come, the call or chirp of the grasshopper issuing from stridûlatory organs, which in some families (acridiidæ) make the noise by the friction of the hind legs against portions of the wings or wing-covers, and in other

families (locustidæ) by scraping one wing against the other. Many of the cicadæ have developed a vibrating membrane in the first abdominal segment, and it is this which produces the deafening noise of the "scissor-grinder". (It is only the male cicada which grinds scissors, a fact which inspired the lines of a Greek poet in classical times: "Happy the cicadas' lives, husbands who have voiceless wives.") When a male grasshopper has been chirping in vain for a considerable time, he will remove to a fresh spot, in order to see if his love-song will have a better result there. Often grasshoppers sing in chorus. One male begins chirping, and the others chime in, until the whole field seems full of sound. Then, as if at a word of command, the music is suddenly stilled, but after a time the chorus is resumed. It is easy to watch the female grasshoppers hurrying towards the chanting males. The latter change their tone, their song becomes gentler and more seductive. That the chirping, and not an odour, is what allures the female has been shown by the telephonic transmission of the notes of grasshoppers and crickets.

I should like to give a brief account of the very unusual way in which these insects couple. Whereas generally speaking, throughout the animal kingdom, the male mounts the female, here the male, crawling backwards insinuates his abdomen beneath the female, until she at length is sitting on his back. Then he turns his abdomen upwards, until the two sexual orifices are in contact. There are yet other species in which the male remains inactive, while the female climbs upon his back. Another peculiarity here is that the female is allured into this position by her sense of taste. Consider the mole-

cricket, Gryllotalpa vulgaris, for instance. The male has on his back, between the thorax and the abdomen, what is known as the thoracic gland, a depression containing minor fossæ covered with glandular hairs. In this depression there accumulates a secretion from the glandular tubes, and the female greedily licks up the substance. Between the two anterior fossæ there is an eminence to which the female mole-cricket clings with her jaws during the act of copulation. We see that there is

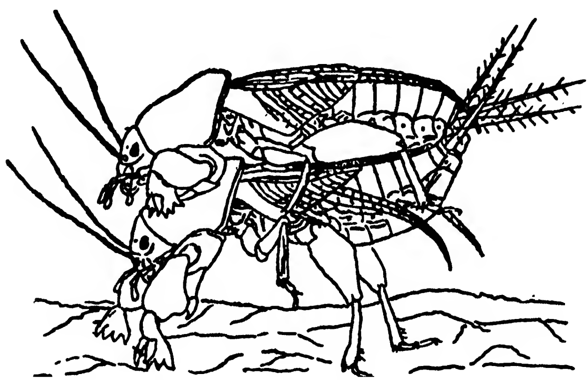


FIG. 50.—MOLE-CRICKET (GRYLLOTALPA VULGARIS) IN THE ACT OF COPULATION

The female climbs on the male's back and is carried about by her husband while the two have intercourse.

not one of the senses which nature cannot turn to account for promoting the maintenance of the species. (See Fig. 50.)

The most conspicuous development of sound as an allurement and a means of wooing occurs in the song of birds, which is loudest and sweetest at the breeding-season, and whose effects are often supplemented by peculiar amatory dances executed by the male. (See plate facing p. 161.) In mammals, too, the uttering of various sounds plays a notable part in the amatory life,

although these wooing notes are less melodious than those of birds. On an earlier page I have referred to the belling of stags, with which the woods resound in autumn.

Very remarkable is the chorus of male frogs, which, for the strengthening of their voices, have distensible sacs opening into the oral cavity. These sacs, which may be paired or single, are blown out with air when the creature is croaking its loudest, appearing in front of the gullet or on either side of the head as whitish bladders. (See plate facing p. 144.) Many fishes make rumbling noises amid the excitement of love-play.

We have studied (above p. 162) how an appeal to the sense of touch is characteristic of the wooing of many male spiders. In the jumping-spiders (salticidæ), love-play takes a somewhat different form. With most extraordinary contortions, the male executes a grotesque dance in front of the wife, thus putting the latter's blood-lust to sleep. Indeed the female jumping-spider is thereby thrown into a sort of hypnotic trance, a state of cataleptic rigidity, in which she permits the act of copulation to take place without resistance.

In many crustaceans, there is no sense but the tactile to evolve stimuli that promote the mutual discovery of the sexes. In some of the copepods, for instance, the males seize any other members of the species that come in their way, whether these be males or females, and palpate with their antennæ. If thereby informed that they have seized a male, they will let him go ; but if they find that they have a female in their grasp, they proceed to effect copulation. Even though such a male copepod has had his eyes extirpated and his antennæ cut off, being thus deprived of his powers of sight and smell, a sense of touch

will enable him to discover whether he has got hold of a female. We learned that the behaviour of rutting toads was similar.

How stimulating certain forms of contact can be, was shown by our study of slugs and snails, which, in order to increase sexual excitement, will lick one another sore with the radula or pierce one another with Cupid's darts.

Speaking generally, pain can become a sexual stimulus, as is shown by the biting which often occurs in human beings during the excitement of the sexual act. Among the South Sea Islanders scratching of the partner with the finger-nails is common during coitus, being a form of caress practised especially by the women.

The stimulating effect of the contact of certain parts of the body is also seen in the billing of birds, in the mutual licking of various mammals, in the reciprocal contact of the tongues, or in the licking of the genital organs with the tongue. In men the sense of touch has indubitably come to play a leading part before and during sexual intercourse; and we human beings possess what are known as "erogenic zones" which react with peculiar readiness when touched, arousing reflex sexual excitement. Among such regions with a peculiarly keen sensibility must be mentioned, before all others, the female breast and especially the nipples. These latter, when they are lightly stroked or sucked, respond by becoming turgid with blood, so that they undergo a sort of erection. Simultaneously the woman experiences sexual appetite, which manifests itself in her genital organs by a stiffening of the clitoris and by an abundant secretion of the vulval and vaginal glands, facilitating the introduction of the penis. For many women, this pre-

liminary love-play is more important than the sexual act in the narrower sense of the term. Normally in woman, and above all in a woman who has previously had little or no sexual experience, the curve of sexual excitement rises and falls much less quickly and steeply than that of the male, but preliminary love-play with the breasts and nipples will often enable her to attain to the sexual orgasm and therewith to adequate sexual gratification which would otherwise have been lacking. One reason, and a very important one, why so many women remain unsatisfied in conjugal life, and why, in extreme cases, the sexual act becomes positively repulsive to them, is that their husbands pay no attention to these physiological and psychological peculiarities of women. A man is far too apt to be solely concerned with the immediate gratification of his own detumescent impulse.

Breasts and nipples apart, it is, above all, the regions of the body where skin passes into mucous membrane that constitute erogenic zones. The mouth and the anus preeminently! A skilfully conducted preliminary love-play, promoting a harmonious course of excitement in the partners to the sexual act and leading to simultaneous orgasm and ejaculation, is, furthermore, of great biological moment, inasmuch as trustworthy observation shows that in this way the likelihood of conception is greatly increased.

A famous historical instance is that of the Empress Maria Theresa, whose marriage had for a considerable time remained infertile. She asked the advice of her physician-in-ordinary, Gerhard van Swieten. One of the items of his reply was: " I am also of opinion that Your Majesty's genital organs should be stimulated for a

long while before the act of intercourse." The measures adopted were quickly successful, and thereafter Maria Theresa gave birth to no less than sixteen children.

Among the stimuli which are generally supposed to have a powerful exciting influence upon the sexual sensibilities are the bright colours and other adornments of many animals. Most conspicuous, in this respect, is the colouring of many butterflies and birds. The males are usually far more ornate than the females, and the former, when wooing, make an elaborate display of these beauties and decorations. Every sportsman is familiar with the pairing dances of black-cock, mountain-cock, and bustards, during which they not only prance and spread their feathers, but also utter peculiar calls. The cocks are so much occupied with this important business that it is as easy to shoot them as a sitting barndoor-fowl. Another striking feature of the affair is the little attention that the hens seem to pay to the antics of their gallants. At long last, however, they accede to the desires of the wooer. Yet there is a lack of evidence to show that the hen always gives the preference to the handsomest male, and that the bright colours of the latter have therefore been evolved (as Darwin supposed) through sexual selection. Often enough we find that the shabbiest among the rivals proves the successful suitor. We should be ascribing a more cultivated taste to the hen-birds than they actually possess if we were to suppose them guided in their choice of a mate by the fine feathers that make a fine bird. Besides, the same antics, the same struttings in front of the hens, are performed by the cock birds in species that lack the splendid adornment of black-cock and mountain-cock. For instance, a cock-partridge will

plume himself and dance before his mate. Biologists have no resource but to admit that they are still unable to account for these male insignia of beauty. Beyond question, the theory of sexual selection does not explain the facts. There would be better grounds for supposing that the dinginess of the hen birds is due to sexual selection! They have to sit on their eggs for weeks, and obviously the least conspicuous among them will be the most likely, in these circumstances, to escape the attention of enemies. Maybe these differences in colour are, in part, at least, dependent upon metabolic processes. In the production of the eggs, which are so richly supplied with yolk, a great call is made upon the resources of the hen bird's store of nutriment, and we may well suppose that the cock devotes his superfluity in this respect to ornamental purposes. In youth, the cocks and the hens are very much alike. The masculine secondary sexual characters of brightly-feathered birds do not appear until the testicles ripen, so that we are led to think that the females are birds that have remained at a comparatively primitive evolutionary stage. There can be no doubt, however, that the bright colours assumed at the rutting season by the female genital organs in baboons and chimpanzees, associated with a marked swelling of the whole rump, are a sexual lure, attracting the attention of the male to the female's sexual orifice. In these animals, moreover, the females are at such times extremely forthcoming, and give the plainest possible indications of their readiness to couple.

In male animals, too, attention is sometimes directed towards the genital organs by bright colours and striking shades. A conspicuous example of this is afforded by the

vervet, Cercopithecus pygerythrus, a long-tailed monkey which inhabits the veldt of southern and eastern Africa. In this creature, the scrotum is of a turquoise-blue colour and the foreskin is scarlet, so that the organs stand out conspicuously against the surrounding white hairs. Many biologists are inclined to regard the descent of the testicles through the inguinal canal into a pendent and sometimes brightly coloured scrotal sac as a device for promoting sexual excitement in the female. It is certainly a remarkable fact that in certain savage races of man among which the wearing of clothes has not yet become customary, the region of the external genitals is decorated by coloured tattoo-marks or has attention drawn to it in the males by the wearing of an extremely conspicuous penis-sheath. (See Fig. 51.) It seems almost indubitable that the wearing of a "fig-leaf" or loin-cloth did not originate from a sense of shame but from a desire for local decoration. In many female savages we find the custom of shaving the pubic hair and of decorating the shorn triangle with tattoo-marks. (See Fig. 52.) The notion that tattooing was a preliminary stage to the adoption of clothing and was a means for veiling nudity cannot be sustained. Tattooing has spread from savages to civilised races, being among the latter practised especially by sailors and prostitutes. Beyond question the imitations of the male genital organs on medieval armour subserved the same purpose of promoting sexual excitement.

On a number of the South Sea Islands, long and pendent labia minora are regarded as a great ornament. A girl's mother will begin to pull upon the labia minora when the child is quite young, and the task of keeping

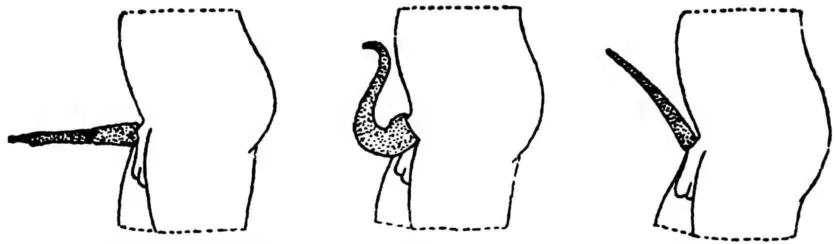


Fig. 51.—Penis-Sheaths worn by the Aborigines of New Guinea. (*After* Schultze.)

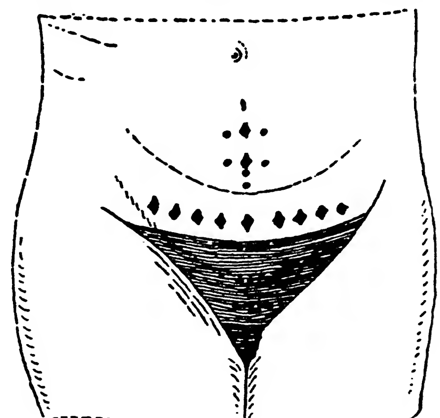


Fig. 52.—Tattooing of the Pubic Region in a Pelew Islands Woman.

up this practice is allotted to certain elderly men. Later, the girls continue it themselves, until the labia minora and also the clitoris become greatly hypertrophied. The most striking development of this particular malformation is seen in what is known as the " Hottentot apron " of Hottentot and Bosjesman women. The Hottentot apron is produced by an excessive enlargement of the clitoris and the labia minora, which hang down as a huge bifurcated fold out of the vulval cleft in front of the vaginal orifice. In full-grown women, this " apron " may sometimes be as much as four inches long. Since already at birth the female children of these races have abnormally enlarged clitoris and labia minora, we have in their case to do with a congenital malformation, which is, however, artificially fostered after birth, since the Bosjesmans and the Hottentots regard it as ornamental. It seems probable that masturbatory practices are also in part responsible for the elongation of the labia minor. (See Fig. 53.) There is no disputing about tastes ! The men of these same races also consider excessively large buttocks as one of the greatest charms in a woman. There are other black races in which the women are fed like prize cattle, becoming transformed into obese creatures weighing several hundredweight and scarcely able to walk. Casati tells us of a negro king who had six wives, every one of whom weighed more than four hundredweight. Nor have we civilised human beings any ground for turning up our noses at these benighted savages ! It is not so very long since women with wasp-waists were regarded by us as the ideals of feminine beauty. The recent fashion, which is now happily past, of regarding excessive slim-

ness and the artificial repression of all feminine bodily characters as beautiful, was another of these aberrations of taste.

We have now to consider a peculiar kind of secondary sexual character, which serves partly as an ornament to allure the female, and partly as a weapon of offence and defence when the males are fighting for possession of the females. The character in question may fulfil now one

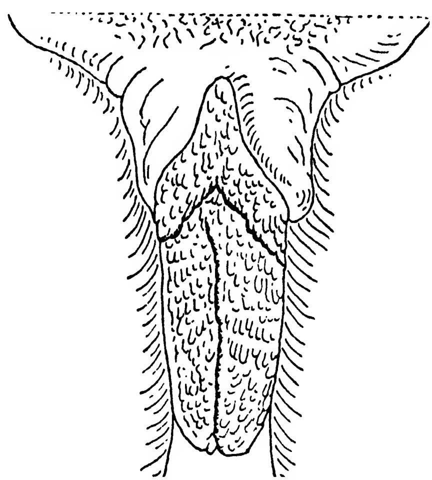


FIG. 53.—THE "HOTTENTOT APRON".

purpose, now the other, and now both together. This twofold significance is especially well seen in the case of the beckoning-crab (Uca cultrimana, White), which has adapted itself to a terrestrial life, so that it does not merely seek its food as do other crabs on the seashore between high-water mark and low, but goes inland and, with its pointed legs, climbs up bushes to nip off their leaves. When these crabs leave the sea, they fill their gill-cavities with water, so that the gills can be kept moist

and continue their function as respiratory organs although the animal spends many hours in the air. The females of the beckoning-crab have small and weak claws, whereas in the males one of the claws is enormously developed, so that its length exceeds that of the animal's body. This huge claw is further distinguished by being very brightly coloured.

The claw in question has several functions. The male crabs live in holes they have dug in the earth, using the great claw to barricade the entrance so effectively that no enemy can take them by surprise. At the pairing season, however, the crabs emerge from their retreat, and each of them executes an excited love-dance before the lady-crab of his choice. He plants his legs in such a position that his body is directed obliquely upward, while he swings about it, like a flaming sword, the huge claw. (See Fig. 54.) Any other males that approach to make love to the chosen belle are fiercely attacked. In these combats, each of the males tries to seize his rival's great claw and break it off. The victor then resumes his love-dance before the female, until the latter, impressed by his beauty and his strength, affectionately draws near. Thereupon she is seized by the male, and (very roughly) dragged off to his hole in the mud, where copulation ensues.

The beckoning-crab gives us a hint how such secondary sexual characters may have come into existence, for we cannot conceive how they could serve as an important accessory to courtship unless they had already attained a considerable size. Probably the great claw did not primarily function as a means of courtship, but only as a door to the crab's hole, developing in adaptation to this

peculiar mode of life. Secondarily, however, as it grew, it became a striking sexual character, and was now instinctively pressed into the service of the art of love-making. There has occurred a remarkable change of function, or rather, an expansion of function.

Similarly expanded functions as means of combat and means of wooing are subserved likewise by the antlers

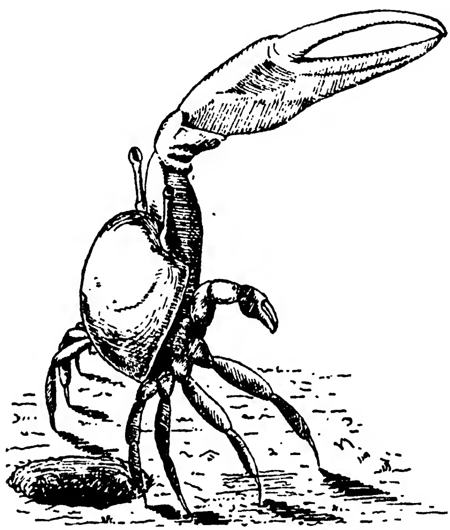


Fig. 54.—Love-Dance of the Male Beckoning-Crab.

of the stag, the huge mandibles of the stag-beetle, the horn of the rhinoceros-beetle, the lion's mane (which helps to protect the animal's neck from bites), the stickle-back's spines, the cock's spurs, and many similar appliances—all these being useful both in the struggle with rivals and in the wooing of the favour of females. When the wooing has been successful, the male, in many cases, has yet other appliances with which to hold his

mate in a firm grip and to aid in the completion of the act of intercourse. Often the virile member itself serves literally as a copula or connecting-link, for it becomes greatly distended after introduction into the female's sexual orifice, thus locking male and female together in a copulatory act which lasts for hours or even for days. We see this, for instance, in many insects, in which during copulation the sexual organs become so closely interlocked that the animals cannot be separated from one another without doing them grave injury.

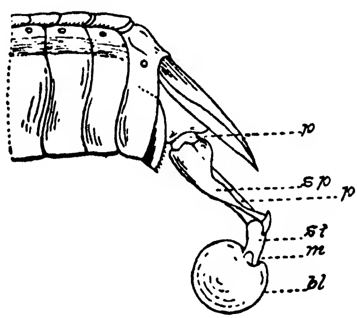


FIG. 55.—COCKCHAFER'S ABDOMEN, SHOWING EXTRUDED COPULATORY ORGAN.
p, penile sac. *sp*, chitinous sheath of the penis. *st*, stalk of the penis-bladder.

In years when cockchafers are plentiful, we see clinging to twigs female cockchafers with the males hanging down behind them, attached to their wives by the penis. At the beginning of copulation, the male cockchafer mounts his wife from behind, and in this position introduces his penis. After a time he relaxes his grasp of his mate, and lets himself drop backwards, whereby the remarkable position above described is produced. (See Fig. 55.) As the illustration shows, the male beetle has a penis-bladder by which he thus becomes coupled

to his mate. The " locking " of dog and bitch in sexual intercourse has already been described.

An even stronger chaining together of a copulating pair than is effected by mere pressure arises when, as occurs in many animals, the penis is beset by backwardly directed chitinous or horny spines and barbs which, when the organ is erect, offer a vigorous resistance to any withdrawal of the organ from the vagina. Such an equipment of the virile member is met with, not only in animals at a low level in the animal kingdom, such as worms and insects, but also among mammals—the guinea-pig, the porcupine, the cat and many monkeys. Manifestly this arrangement serves, not only to anchor the copulating pair to one another, but also for the mutual increase of pleasure in the sexual act. (See Figs. 56, 57, 58, and 59.)

In this as in so many other things, man imitates nature, artificially reproducing what he lacks or what he has lost in the course of phylogenetic evolution. The Fuegians, for example, make, out of short, thick hairs cut from a mule's mane and attached to a string, a ring known as a " guesquel " which is slipped over the glans penis, and which, notwithstanding or because of the painful friction it produces in the vagina, arouses extreme sexual excitement in the woman. I have had occasion, more than once in the course of the present work, to allude to the close connection that can often be observed between pain and the voluptuous sensation. Let me remind my readers of the Cupid's dart of the snail. In animals of the cat family, in lions and tigers as well as in our domestic cats, the females often utter loud cries of pain during the sexual act, only to give themselves up to the accompany-

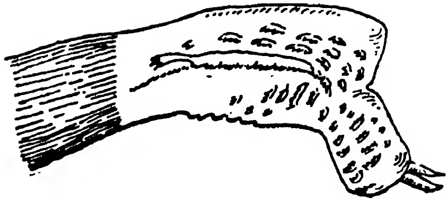


FIG. 56.—GLANS PENIS OF GUINEA-PIG SEEN FROM THE SIDE, SHOWING THE SPINES WITH WHICH THE ORGAN IS BESET.

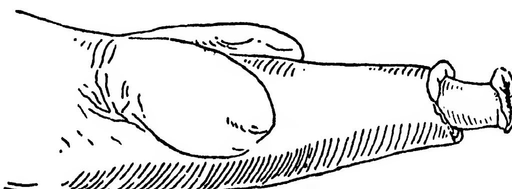


FIG. 57.—ANTERIOR PART OF THE PENIS OF A RHINOCEROS (CERATORHINUS SUMATRENSIS), SHOWING LOBATE CORPORA CAVERNOSA.

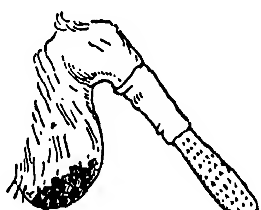


FIG. 58.—PENIS OF THE LEMUR, OTOCLINUS ELEGANTULUS.
The glans is covered with barbs to increase friction.

FIG. 59.—PENIS OF THE MAKI (LEMUR MACACO).

ing pleasure all the more willingly. (See plate facing p. 209.)

Men do not even shrink from painful operative procedures when the purpose of these is to increase the intensity of voluptuous sensation in their wives. The Dyaks of Borneo, on reaching the age of puberty, have a hole bored in the glans penis, and keep the channel thus made open by thrusting into it a pigeon's feather dipped in oil. Before intercourse, the feather is replaced by what is termed an " ampallang ", a little metal rod shaped like a dumb-bell, for it ends in two balls which are

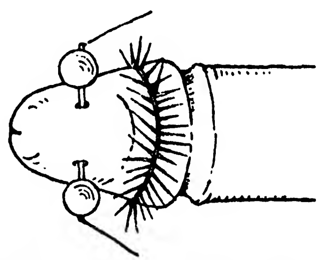


FIG. 60.—PENIS OF AN INDIGENE OF CELEBES, WITH AN AMPALLANG AND A RING OF BRISTLES.

either smooth or set with bristles. The Dyak women regard the non-use of an ampallang by a husband as sufficient ground for divorce. (See Fig. 60.) The figure shows the penis of one of the aborigines of Celebes, armed, not only with an ampallang, but also with a ring of bristles round the glans. By the use of these means of stimulation, a man is only providing what his ancestors of long ago possessed. In the early embryonic condition, the human glans is covered with cutaneous spines, which atrophy as growth proceeds. Cases are known, however, in which this crown of spines has persisted, to some extent, in an adult human being. (See Fig. 61.)

The most important male organ, not only for the sexual stimulation of the female but also for the voluptuous pleasure of the male, is the mammalian glans penis, which, as previously explained, may swell up markedly after introduction. (See Figs. 57, 58 and 59.) By the

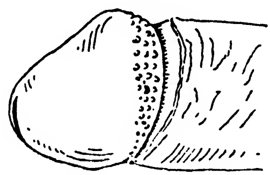


FIG. 61.—PENIS OF A YOUNG MAN, SHOWING ON THE CORONA GLANDIS SEVERAL RINGS OF SMALL HORNY PAPILLÆ.

typical to-and-fro movements of sexual congress, the stimulation is intensified. In females, on the other hand, the clitoris, which is the homologue of the penis in the male, is the centre of sexual sensibility. The position assumed by mammals in coitus is such as to bring the penis and the clitoris into direct contact. In

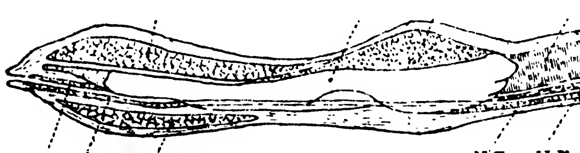


FIG. 62.—DOG'S PENIS IN LONGITUDINAL SECTION TO SHOW THE PENIS-BONE.
ur, urethra. ***us***, corpus cavernosum urethræ. ***es***, terminal corpus cavernosum. ***ps***, corpora cavernosa penis. ***sk***, nodular corpora cavernosa, whose erectile enlargement leads to the "locking" of dog and bitch.

rodents, bats, and dogs, there is a bone, the penis-bone, imbedded in the virile member. During erection, it presses strongly against the anterior part of the glans, or may even project from the glans. This also serves to increase the stimulating effect. (See Fig. 62.)

Whereas in the higher animals there are no special clasping organs for exclusive use in sexual intercourse, the male usually seizing the female by his anterior limbs or biting her on the neck (as is typical of the emu—see plate facing p. 232), in many of the lower animals special sexual clasping organs exist. Clasping organs of this kind are the before-mentioned thumb callosities of the front limbs of male frogs and toads, which undergo enlargement at the rutting season. Many water salamanders, before depositing their spermatophores, clasp the female in the region of the neck with their hind-legs, where, on the inner surface of each thigh, there forms at the pairing season a warty thickness which gives the limbs a firm grip. In some of the crustacea, the antennæ have been transformed into powerful grasping organs ; and in others the males have, on the front part of the head, eminences recalling a stag's antlers and serving to hold the females fast. In Dytiscus marginalis, one of the commonest of the predacious water-beetles, the fore-feet of the males bear suckers with which they can cling to the smooth wing-cases of the females.

Homologous suckers are found in other classes of the animal kingdom. It is with their aid that the remarkable trematode worm, Diplozoon paradoxon, effects a union with its mate—a union which may be termed a lifelong copulation. The diplozoa are hermaphrodites. The sucker with which the union is effected is upon the abdominal surface, corresponding precisely to a shallow cup in the skin of the partner's back. Very early in life, before sexual maturity has begun, two worms become thus mutually apposed, so that their united bodies form an X, or St. Andrew's cross. Thereafter the two surfaces

of the respective bodies grow together along the plane of junction so that the worms can no longer be detached. The pair has become a sort of artificial Siamese twins, and since, as soon as sexual maturity occurs, the seminal duct of each become united with the partner's oviducts, the twins remain for the rest of their lives in a condition of mutual copulation.

The diplozoa are parasitic in the gill-cavities of bream, carp, roach, etc.

Even more remarkable, if possible, is the behaviour of another trematode worm, Distomum hæmatobium, parasitic in the blood of human beings in tropical climes. The animals are of separate sexes. The male is short and broad, the female long and narrow. By turning the edges of its body in beneath its abdomen, the male forms itself into a tube, known as the canalis gynæcophorus, into which it takes its wife. Thus united, the two animals spend the rest of their existence together.

Enough instances of this kind of union have been given. Passing now to consider the act of copulation between animals in which the sexes live apart, we shall find various other ways in which the male holds the female fast. With few exceptions, coitus takes place in accordance with one general type. The diagrams, sketches, and photographs which illustrate the present work will show the nature of that process much better than could long-winded descriptions. (See Figs. 63 and 64.) In general the male covers the female from behind, the female sitting, lying, or standing to receive him. We must content ourselves with studying a few peculiarly typical examples belonging to different classes of animals.

Let me remind the reader that the male and female

sexual orifices are not always brought into contact in pairing. For instance, in spiders (as we have learned), the male transmits his sperm to the female's sexual orifice with the aid of his maxillary palp. (See above, Fig. 40.) Indirect transmission of the seed also occurs in dragon-flies. The sexual orifice of the male is on the

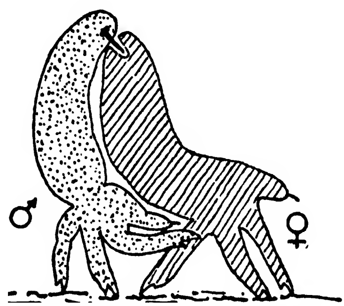


FIG. 63.—BODY-LICE COPULATING.

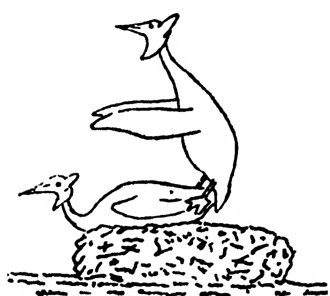


FIG. 64.—CRESTED GREBES (PODICEPS CRISTATUS) PAIRING. (*After* HESSE.)
The male stands upright upon the crouching hen-bird.

ninth abdominal segment at the posterior end of the body, whilst the place from which the semen is actually received by the female is near the front of the body, on the second and third abdominal segments, which are variously constructed in different species of dragon-flies, but always comprise a bottle-shaped or saucer-like

depression for the temporary storage of the sperm. The first act of the drama consists in a doubling-up of his body by the male so that he can fill this semen-container with sperm out of his own sexual orifice. Thus prepared, he sets out in search of a female and seizes his chosen mate with his legs, just as he seizes his customary prey. Then the male grasps the head or the front part of the thorax of the female in his abdominal pincers, relaxes the grip of his legs, and flies away dragging her behind him through the air, to settle down upon a rush. Now it is the female's turn to be active in the fulfilment of conjugal duty. She has to bend her abdomen forward and appose her sexual orifice (which, like that of the male, is situated at the posterior end of the abdomen) to the semen-transmitting apparatus of the male, from which she sucks the sperm into her body. As our illustration shows (plate facing p. 192), when in this attitude, the two insects form a heart-shaped figure.

Hunger and love are the two impulsive energies that sustain the lives of individuals and species. Many animals manage to combine the gratification of the two desires. Just as, during the banquets of the Greeks and the Romans, feasting and venery were often practised in brief succession, so do certain robber-flies copulate while feasting. The female of the little Bittacus tipularius is found in damp places hanging down from a tiny twig or from a blade of grass, which it grasps only with its long front legs, its abdomen swaying loosely, and the two other pairs of legs swinging freely to and fro in the air. The creature seems to be asleep, but it is only feigning. Should a fly come within reach, the victim is promptly seized with the free legs and carried to the

FIG.

FIG

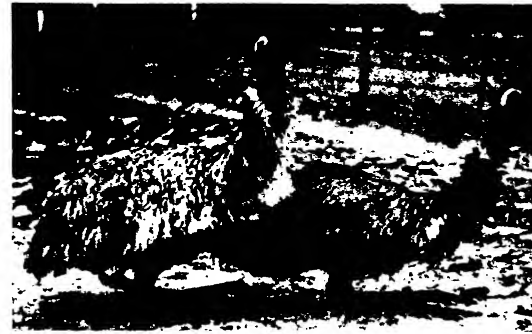


FIG.

FIG

K. M. Schneider

WOOING AND WEDDING IN THE EMU

[face p. 232

mouth, through which the juices are greedily sucked. Soon a male bittacus appears on the scene, and hangs from the same attachment with its abdomen towards that of the female. Now it sinks its proboscis in the captured fly and begins also to suck. Meanwhile, as if

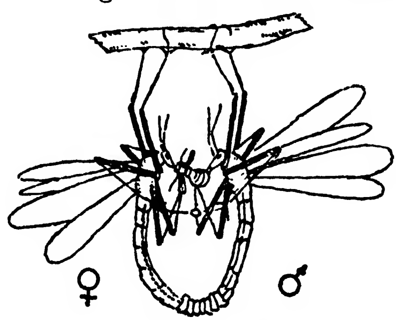


FIG. 69.—BITTACUS TIPULARIUS, COPULATING

involuntarily, the abdominal extremities of the two bittaci seek one another, and the pair engage in the sexual act. Hours will pass before both hunger and love are satisfied. Then the two separate. (See Fig. 69.)

We have already made acquaintance with the anoma-

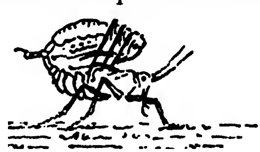


FIG. 70.—BOREUS HIEMALIS, COPULATING.
The female sits on the male's back.

lous position adopted for copulation by the grasshoppers, in which the male pushes himself backwards beneath the female, or the female, allured by the sweet secretion of the male's thoracic gland, climbs on his back. A similar position is adopted in copulation by Boreus hiemalis, but here the male deliberately takes the female upon his back. (See Fig. 70.)

In the toads and frogs there is no penis or anything resembling it. The male mounts the back of the female and squirts out his semen simultaneously with the evacuation of the ova, this latter process being assisted by the pressure of the male's front legs. (See plate facing p. 144.) Sometimes with his hind-legs the male actually drags the strings of ova out of the female's body. Here sexual feeling is intensified by the close contact of the surfaces of the male and female bodies. It seems obvious, too, that the ejaculation of the reproductive products is in itself a sexual stimulus.

In almost all animals extreme excitement is manifested by both sexes at the moment when the semen is being ejaculated, this excitement being exhibited in the form of peculiar convulsive tremors which affect the whole body. Since the female makes such movements as well as the male, we must suppose that the semen directly excites her. Such is certainly the impression produced when we watch the female crested salamander, whose body twitches all over at the moment when her cloacal fissure comes into contact with and sucks in the spermatophore which has been placed ready for her acceptance by the male.

Among the vertebrata, when, in the scale of ascent, we reach the reptiles, we find that a copulatory organ has at length been formed. Both in lizards and in snakes this is projected from the cloaca, and becomes erect through distension with lymph. Let us study the love processes in the case of the common adder. (See plate facing p. 97.) When the sexual impulse begins to stir within them, great numbers of adders often assemble in a sunny spot. Now a strange wooing begins. The

creatures lift the front part of the body high in the air, and execute a love-dance characterised by rhythmic swaying and by protrusion of the tongue—movements resembling those made by a cobra when an Indian snake-charmer is piping to it. After a time, a pair will separate from the throng, and now the male slowly climbs on the back of the female, incessantly licking her body as he does so. Simultaneously he twists the end of his tail round the tail of the female adder, and wriggles until he has brought his sexual orifice into close apposition with hers. When this has been achieved, the snakes lie as they are for a long time, quiescent so far as movement is concerned, although the female is perpetually on the watch. Should danger threaten, she will serpentine away to some safe hiding-place, but the male is so closely locked to her that she drags him after her.

Love-dances characterised by the display of masculine beauties occur in almost all animals, but in no others with so much elaboration as among the birds. Little blue-tits show off before their wives with as much zest as do pheasants, black-cock, and mountain-cock, or partridges and emus, continuing their antics until the hen-bird surrenders to the embrace. At the mating season the stork, in general a bird of the utmost gravity, throws his dignity to the winds, and thinks only of the gratification of his impulse. On the side of their lofty nest, the father-stork and the mother-stork stand facing one another, their heads thrown far back, and both of them clattering vigorously with their mandibles. Next the cock-bird, flapping his wings and twisting his neck, cuts the quaintest capers, until, at length, he flies on to the back of his mate, who has been standing quietly and

looking on. Seizing her neck in his beak, he effects the act of copulation. (See plate facing p. 208.)

A wedding among the emus is a very characteristic affair. After prolonged wooing and showing-off on the part of the male, the female bird shows her readiness by crouching on the ground. Thereupon the male likewise cowers behind his mate, and, in this crouching posture, draws nearer and nearer to her. At length, while she squats closer and closer to the ground, he climbs on her back. The intense excitement of the pair is shown by the S-shaped curve of their necks. Now the cock-emu pecks so fiercely at the hen-emu's neck that the feathers fly. When the male has finished treading her, the female, exhausted, often remains cowering on the ground for a long time. (See plate facing p. 232.)

Copulation in a similar crouching posture also takes place in lions, llamas, camels, and dromedaries. (See plate facing p. 209.) The dromedary stallion behaves like a lunatic at pairing time, honking and " bubbling ", biting and kicking, and even turning against his master. He goes completely off his feed, and only one thing in the world can set him right. As soon as he sees a female, he rushes after her, making loud gurgling and snorting noises, the bellowing-sac on the front of his neck being greatly distended the while. At length the mare dromedary crouches down, and coitus is effected in this position.

Much more amiable and charming are love-sport and its upshot among roe-deer. The rutting season in these animals begins in July and ends in the middle of August. In the roe-buck, sexual excitement begins to manifest itself by great restlessness and pugnaciousness. As in most of the bi-ungulates (cloven-hoofed animals, artio-

dactyla), the females are continually pursued by the males, and every rival buck is fiercely attacked. When these combats are going on, the does are disregarded for the time, and not infrequently a young buck seizes a favourable opportunity for tasting forbidden fruit. The older does are, as a rule, quite as much excited as the buck, and show their readiness by a clear, piping call, to which the buck responds in a much deeper tone. The doe allows the buck to cover her without making any resistance. Our illustration (see plate facing p. 160) shows roe-deer engaged in the brief caressive act, in which they almost look as if they were kissing one another, and which immediately precedes coitus. Although copulation is effected during the summer months, the young are not born until the following May, so that they are carried for nine months, the pregnancy seeming of very long duration. The explanation is that, although the ova are fertilised in the Fallopian tube very soon after intercourse, and begin to develop there, they descend within a few days into the uterus, and there development is arrested until the end of December. Then the later stages of embryonic life are traversed with considerable rapidity.

Very impressive is the act of coupling in the largest of terrestrial mammals, elephants, whose behaviour in this respect has been closely studied of late years. Here, likewise, there is a lengthy period of preliminary dalliance, in which the bull-elephant and the cow caress one another with their trunks. The vaginal orifice of the female is very thoroughly smelt, while she obligingly holds her tail to one side. Meanwhile the bull-elephant becomes more and more excited, as is shown by the change in the

long penis hanging out of its sheath, which gradually becomes erect in an S-shape. When the cow-elephant at length complies, the bull lays his trunk on her back and mounts her, embracing her body between his fore-legs. While he is doing this, his penis behaves almost as if it were an independent living creature, moving from side to side and upwards and downwards, until at length its point discovers the vulval orifice. The period between the introduction and the withdrawal of the penis is only fifteen or twenty seconds. Ejaculation ensues after a few brief thrusts.

Now that we have considered this giant among the terrestrial mammals, let us turn for a moment to the largest of all mammals, the whale. At the pairing season, whales swim side by side for a time, then turn belly to belly, and in that attitude the introduction of the penis is effected. Then the copulating pair assume a vertical position in the water, with their heads projecting above the surface.

Among monkeys, the female usually has all four limbs planted on the ground, while the male holds her sides between his hands and copulates with her in a half-standing posture.

Whereas copulation among elephants, horned cattle, horses, etc., lasts no more than a few seconds, and ejaculation is effected after perhaps a dozen short thrusts, the boar, when he has penetrated, remains for a quarter of an hour motionless upon the sow's back, while in bears and many other mammals coitus may last for more than an hour.

The love of the sexes is an egoistic love, which in its primitive form aims only at the gratification of the

detumescent and contrectative impulses. Man is the first of living creatures to sublimate this impulse into the spiritual. Out of an impetuous urge which drives the sexes to mate, there has grown another, an altruistic form of love, already manifest in many of the lower animals, and attaining a very high development in civilised human beings. This altruistic love leads the parents to care for their helpless offspring, and often to sacrifice themselves. It is the same development of love which has led to the formation of families, hordes, and States. Here, however, I am impinging upon the topic which properly belongs to a different book. All that remains for us to consider in the present work is how the sexual impulse and love manifest themselves among savages.

CHAPTER EIGHT

LOVE IN HUMAN BEINGS

WE have no records to show how love developed among our ancestors of long ago when they were transcending the Simian stage to become human beings. That was the period during which the sexual impulse of these bipeds became conscious ; and with the growth of consciousness there became operative magical or religious or moral influences, so that pure instinct could no longer have free rein. Certain kinds of activity were subjected to taboos. Ethical sentiment and shame began to demand their rights. The life of contemporary savages, though they are often spoken of as " primitives ", cannot supply us with any information concerning the earliest days of humanhood. It is many hundreds of thousands of years since a truly primitive man made his appearance in the world. In the biological sense, our " savage " contemporaries are by no means primitives. Their deep-rooted manners and customs, their shame or their lack of shame, their marriage codes, their orgiastic festivals, the magic ceremonial which surrounds their sexual life, the couvade, child-marriage, and various other institutions which seem to us so strange, are, one and all of them, the outcome of a lengthy process of social evolution. A further difficulty in the study of such matters arises because, in almost all cases, the original mode of life of these indigenes has been modified by the

preaching of missionaries and the influence of other members of the white races, with the result that many ancient customs have disappeared, or are sedulously concealed from western eyes. Just as, in the civilised world, the intimacies of our sexual life are veiled in mystery, concealed even from close intimates, so among the "primitives" of our day are conjugal and extra-conjugal relations restricted and obscured by countless prohibitions.

We can assume with considerable probability that the sexual life of our genuinely primitive ancestors must have differed little, as far as physical technique was concerned, from the amatory life of primitive man's immediate animal progenitors—or, perhaps, it would be wiser to say, from that of the creatures which, anatomically and physiologically, stand closest to man. As among all the higher mammals, we may presume the natural position in the sexual act to have been coitus a posteriori; this supposition being confirmed by mural drawings in the cave of Comparelles in Dordogne—drawings which belong to the early Stone Age between the Aurignacian and the Magdalenian epochs. (See Fig. 71.)

No more than his animal cousins, had primitive man any understanding of the significance and purpose of copulation. What brought the sexes together was not a "reproductive impulse", not a desire for offspring, not a conscious decision to maintain the species. When, at certain seasons, the sexual hormones were poured abundantly into the blood, stimulating the sexual centres in the nervous system and arousing the detumescent and the contrectative impulses, man and woman sought one

another out, and, gratifying their lusts, unconsciously fulfilled nature's supreme purpose.

Even now there are many savages who remain unaware of the meaning of sexual intercourse, of the relationship between coitus and fertilisation, and of the part which the father plays in the affair. They do not know that the seed is prepared in the testicles, that it contains

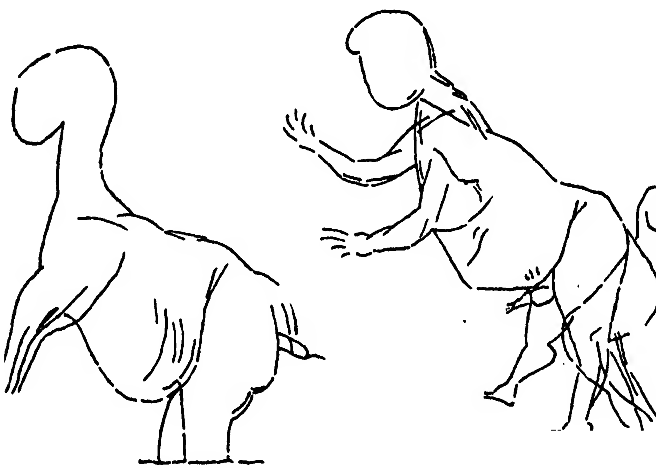


FIG. 71.—MURAL DRAWINGS FROM THE CAVE OF COMPARELLES.

ingredients which stimulate the egg-cells to develop and transmit paternal characters to the offspring. A lack of understanding of these causal connections probably explains why the sexual activity of " savages " is, from earliest youth, subjected to so little control, if to any at all. Just as a child eats to allay the pangs of hunger as soon as these are felt, doing so instinctively, and without any idea of the processes of digestion, so, in youthful innocence, does a savage boy or girl enter into intimate relationships with a playmate of the opposite sex—quite

openly, and directly the contrectative impulse stirs. Their parents see no reason for interfering by the utterance of prohibitions or warnings, but regard these indulgences as they would regard a childish dance or any other pastime, any other expression of vital energy and joy. Even the grown-ups of many aboriginal races, for instance the inhabitants of the Philippines and of a number of the South Sea Islands, see nothing amiss in the public performance of coitus. Just as, in former days, man was naked and not ashamed, so had he no thought of any impropriety in coupling without concealment. Nay more, in civilised countries, our children at first know nothing of shame. A child would without let or hindrance follow all its natural promptings were it not that parents and other grown-ups stretch it from earliest youth upon the Procrustes' bed of morality and convention, continually sermonising to the effect that this, that, and the other is improper.

To us Europeans, whose "naturalness" has been damped down by the workings of civilisation, religion, and convention, the frankness, the straightforwardness, of the sexual life of savages seems so uncongenial, so amazing, that many travellers have depicted it in the blackest colours. Others, those who have made a cult of the "natural", have, on the other hand, regarded it as paradisiacal in its innocence. The romanticism of some travellers and investigators and the sanctimoniousness of others, conjoined with an incapacity for freeing our minds from European prejudices and grasping the simpler mental processes of less sophisticated peoples, have led to grave confusion. Those whom we call "savages" are not more "savage" than we. Their

sexual relations are certainly no more immoral than our own. These brethren of ours who are closer to mother earth than we, are only more natural, are less compelled than we to guide their actions by conventional rules and to veil their sexual doings in darkness. Still, although there is not among them the gulf between what may be done in privacy and what may be freely discussed in public that has been established by the moral code of Europe and America, it seems desirable to insist once more that contemporary " savages " do not follow their impulses in accordance with the promptings of unfalsified biological laws. Magic and taboos and religion and ethical codes have, in the course of the long ages of human development, imposed the rules of custom and convention upon all the races of man, the main difference being that among the semi-primitives, who are simpler than ourselves, such codes as they have are, as a rule, more strictly observed even in the dark than are the moral laws we civilised beings pretend to obey. Seligmann, Koch, Grünberg, Rivers, and other anthropologists have done much to throw light upon the psychology of savages. Bronislaw Malinowski, however, equipped with all the armamentarium of the skilled ethnologist, has been the first to make us acquainted with every detail of the behaviour of savages in such matters. He spent many years in the Trobriand Islands, a group of small islands east of New Guinea and south of New Britain, living among the aborigines and acquiring their confidence. The results of his investigations have been published in his momentous work, *The Sexual Life of Savages*. We owe him all the more gratitude for his researches because, owing to recent advances in the

means of communication, the world is rapidly growing smaller. The ancient manners and customs of primitive tribes are vanishing ever more quickly before the " blessings of civilisation "—before prostitution, drink, and venereal diseases.

For the first time we have been provided with a lively picture of the mental and bodily behaviour of a simple group of " primitives ". Malinowski's observations were made without prejudice, and his statements are based upon information derived from shrewd questioning which was frankly answered by his Polynesian intimates. In the pages that follow I shall be mainly guided by his account. The organisation of social life among the indigenes of the Trobriand Islands is matriarchal. In their village communities, blood relationship is traced exclusively through the mother, and social behaviour is entirely subordinated to the mother-right. They do not recognise that the father has any part in producing a child. Children are reincarnated souls. When a man dies, his spirit leaves his body and wanders to " Tuma ", the Island of the Dead, where these disembodied souls lead a life resembling that of our earth-bound selves, but comparatively free from care. What appears to be the new life of a child derives only from reincarnation. The spirit-baby is floated safely across the sea upon a piece of driftwood. If it be beautiful, the spirit of the mother or of the father of the woman who is to bear it takes it and sets it upon her head. Thereupon the blood flows abundantly to the head of the predestined mother, and this blood current seizes the baby and carries it down into her womb. Since the maternal blood has to build the body of the child, a pregnant woman ceases to

menstruate, and when two or three periods have been missed the happy Trobriand woman knows herself to be with child.

According to another theory, the child makes its way into the mother's body through her vagina ; not, however, thanks to any intervention upon the part of a man, but because it has slipped in unnoticed when the woman was bathing. However, the child that is to be, cannot enter the vagina until this has been opened. A virgin cannot conceive, since there is no passage by which the spirit-baby can get into her body. Before conception

FIG. 72.—UPPER END OF A HARDWOOD DEFLORATION-ROD.

can occur, the mechanical obstacle of the hymen must be removed, so that the spirit can see its way in. Thus the only part the man who has intercourse with a virgin plays in respect of bringing about the subsequent conception and the pregnancy is that he effects defloration. Coitus, however, is not essential to this clearing of the way. Among many primitive races, similar views to those held by the Trobriand islanders prevail as regards procreation, the only difference being that they fancy a spirit of the woods to enter the mother's body, and they destroy the hymen artificially when a girl is quite young. (See Fig. 72.) It is dangerous, they hold, for a man to

have intercourse with a virgin, since the blood poured out when the hymen is ruptured is poisonous. Many savages have the same belief as concerns menstrual blood. Among certain Central African tribes, defloration is effected by thrusting a bull's horn into the girl's vagina, and, for the better dilatation of the orifice, this deflorator is fastened in place for a time. In India, the penis of a god's statue is used for defloration—a custom which also prevailed in ancient Rome. The statue of Mutunus, the god of copulation, had an erect penis. A betrothed maiden had to rupture her hymen by suitably applying her genital organs to this phallus, thus making sacrifice of her virginity to the god. Contempt for virginity prevails widely among savages, many of whom regard it as disgraceful for a woman to enter into marriage with an unruptured hymen. In some tribes the duty of effecting defloration was incumbent upon the medicine-man, priest, or chief. This custom persisted in Europe throughout the Middle Ages and on until the middle of the sixteenth century as the *jus primæ noctis* or *droit du seigneur*. The lord of the manor had the right, nay it was often regarded as his duty, to take the place of the bridegroom on the wedding-night. On the Loango coast, slaves had to deflower girls when these were quite young; among other tribes, guests were invited to undertake this duty. In Samoa, down to the end of the nineteenth century, defloration was a public ceremony, until the European authorities forbade the rite. Not until civilisation attained a high level was much value ascribed to virginity, although in the rural districts its importance has always remained more theoretical than practical. With the emancipation of women and the general laxity following

upon the war, there has been—in part as the outcome of a misunderstanding of the nature of freedom—a considerable change of view upon the matter in western lands. Apart from this, the old-time contempt for virginity has persisted in the disdain so widely felt for " old maids ".

Even though among many savage tribes the young folk engage freely in sexual intercourse before marriage, it is rare for an unmarried girl to bear a child, and such an act is often regarded with opprobrium.

Although the Trobriand islanders recognised that a mechanical opening of the vagina was an essential preliminary to conception, they failed to understand that the male seed was indispensable to procreation. A husband whose wife should bear him a child while he is away from home for a long time, will, on his return, cheerfully welcome the new addition to the family, and see no reason for doubting his wife's fidelity. If you ask one of these aborigines how a woman can possibly become pregnant without having had intercourse with a man, he will regard your question as incomprehensible and absurd. In proof of their belief that copulation and procreation have nothing to do with one another, the Trobrianders point out that their domesticated swine farrow, although the male piglings are all castrated. They forget that the sows run freely into the wild, and there, of course, are covered by wild boars.

It is because of their ignorance of the physiological consequences of copulation that the Trobrianders believe the man to have no part in procreation. The mother, and the mother alone, engenders the child out of her blood; or, to put the matter more accurately, she nourishes with her bodily juices the spirit-baby which

has found its way into her system, and subsequently, when the child has been born, continues to nourish it with her milk. The brothers and sisters born of the same mother are of the same flesh and blood. The father, on the other hand, is not in any way related to the child.

Social position is transmitted through the maternal line from a man to the children of his sister. This purely matriarchal view of relationship is of the utmost importance as regards the prohibited degrees in respect of marriage and as regards the taboos imposed upon sexual intercourse. Sibs connected one with another through the mother form a close corporation held together by a community of interests and by the ties of blood. The father remains a stranger, an outsider. He is not the father in our legal, moral, or biological sense, but only the man who runs a joint household with the mother and presides over that household. Nevertheless the word father, *tama*, has for the islanders a significance that is strongly tinged with feeling. It is the father under whose loving care sons and daughters pass the days of their childhood; for, matriarchy notwithstanding, the wife takes on the domicile of the husband. At marriage, a wife goes to her husband's home and becomes a member of his village community. Yet, in spite of this, the children do not belong to the father's clan. A child's next-of-kin is its *kada*, its mother's brother; and the place in which the *kada* lives is the village where the child has "freedom of the city" and where it spends its life (until, in the case of a female, removal by marriage). Though the father thus has no rights, he is extremely fond of the children who are not regarded as his offspring. He fondles them and cares for them; he washes and

dandles the infants ; it is his duty rather than the mother's to carry the latest baby about. He is proud of his wife's children, and boasts of their merits. But as the youngsters grow up, the paternal influence wanes, whereas the authority of the *kada* continually increases. Strangely enough, the Trobrianders regard it as reasonable and right that children should have a physical resemblance to the father (although he, according to their view, is not related to them), whereas, all appearances to the contrary notwithstanding, they will flatly deny the existence of any resemblance to relatives on the maternal side. A Trobriander would consider it extremely rude of any one to tell him he was like his mother or one of her kin. If you ask these people how a child can resemble his father, seeing that the father is but a stranger, and has nothing to do with the formation of " his " child's body, the answer comes back : " Take a lump of clay in your hand, and you will shape it by pressing it. So, in like manner, is a child shaped by the pressure exerted by the husband when he lies on his wife."

This contrast between matriarchal principles and paternal affection runs like a red thread through all the social ideas and feelings of the islanders, and leads sometimes to sharp conflict. In domestic economy and in household affairs, equality and the division of labour prevail. Since the family dwells in the father's village and the house belongs to the father, he is its lord. All the same, the wife has a strictly defined and secure position. She is not a slave, not a servant, but issues orders to her husband when occasion arises, for, next to her brother, the wife is the legal head of the family. No doubt the husband enjoys the family prerogatives, but the wife

bequeathes them. Whereas, among primitive peoples, the usual custom is for the husband at marriage to pay a suitable price (in money or in kind) to his wife's parents, among the Trobrianders he receives a dowry the amount of which is determined by the rank of the wife's family. The upshot of this custom is that marriage among the Trobrianders is the fulcrum of power and of the whole economic system,—nay more, it is the fulcrum of almost all their social institutions. In this respect, the Trobrianders occupy a unique position among savages. For instance, the provision of food for the household must mainly be attended to by the wife and her family. Marriage is expected to bring the husband material advantages, for which, from time to time, he makes a return by giving small presents. When he first enters into the marriage, the husband gives his bride's family something, but this gift is not regarded as purchase money paid for the bride; it is no more than an anticipatory acknowledgment of the gifts which, in due course, his wife's blood-relatives will make him.

Within the family, the idea of private property is strictly maintained. The husband and the wife have separate disposal of whatever belongs to them respectively, and they do not inherit one another's possessions in the event of death.

The domestic duties of father and mother are strictly regulated by tribal custom. Women's work is regarded as unsuitable for men, and conversely. The wife has to see to the preparation of food. Men may only cook when they are journeying, hunting, fishing, or on a visit to other islands—when they have left their wives at home. Exception is also made on certain festal occa-

sions. In general, however, to say to a man, "You are a cook," is insulting. There is nothing a savage dreads more than infringing custom, undertaking work which properly belongs to the other sex, or engaging in some occupation which is proper only for those of a lower social status than his own. Among purely feminine tasks, in the case of the Trobrianders, is reckoned fetching water for household uses, and the village well or spring is the chief centre of feminine gossip. As far as gardening is concerned, the heavier tasks are incumbent upon men, whereas weeding and similar light labour are a woman's affair. When a house is being built, the men put the framework together, the women helping in the roofing and in the weaving of the walls. Fishing and hunting are men's work, but the gathering of crabs and mussels is a woman's job. The care of poultry and pigs likewise devolves upon the wife.

Although mother-right prevails in these islands, the chiefs are polygamous. No doubt this is because no one but the husband of several wives, and therefore the recipient of abundant contributions from his wives' relatives, is in a position to fulfil the important social duties incumbent upon a chief. The person of the chief is regarded as inviolable. His head, above all, is protected by a sort of halo of rigid taboos. Only his wives and the few members of the community accounted as equal to him in rank may touch his head in order to cut and dress his hair and to remove the lice with which it is infested. Speaking generally, orders of rank are rigorously observed. The leading caste in a village community is that of the chief and his near kin, who regard the village as their property. Next come the ordinary citizens, who have tra-

ditional rights, but are accounted vassals of the chief. The rest of the population are aliens in hereditary serfdom to the chief, but having the privilege of residence. A similar privilege of residence is possessed by the wives of the chief.

Chieftainship is maintained by a rigid ceremonial—for in general the Trobrianders lay great stress upon rank and dignity. A man of noble descent must physically overtop those of common blood, upon whom it is incumbent to bow their heads whenever they are near him, for the head of an underling must never be higher than that of a chief or a dignitary. When a commoner draws near a group of noblemen squatting on the ground, the former calls from a distance *tokay*, " stand up ", whereupon the men of rank leap to their feet while the commoner goes by with bent head. These courtly ceremonies entail an inconvenience, inasmuch as they make it difficult for a chief to sit quiet on his haunches. Women of rank enjoy the same privilege. If a noblewoman has married beneath her, her husband must always bow his head when in her presence, for on no account must he, in the physical sense, look down upon his wife. The head of his noble spouse is, like that of a chieftain, sacred, and—in theory, at least—must not be touched by her husband even during the most intimate processes of conjugal life. The other taboos imposed by rank must be a great nuisance to a lady of distinguished birth. Since certain foods are forbidden to the blue-blooded, a noblewoman who has married a commoner must eat a different diet from her husband and keep her cooking utensils, table-crockery, etc., for her private use; or else (as more frequently happens) her husband must likewise renounce the foods which are forbidden his spouse.

On great occasions, the sexes are equal as far as persons of rank are concerned. This signifies that a woman enjoys the privileges of her high rank just as if she were a man of the same position, with this exception, that she cannot actually exercise the power attaching to such a position—for instance, she cannot function as chief of a village community.

The Trobrianders divide mankind into four clans, whose totemistic peculiarities are as unalterably inborn as sex, colour, and physique. These peculiarities outlast the individual life, and when, after reincarnation through birth, the spirit reassumes bodily form, it returns unchanged in quality. Even the whites are members of one or other of these four clans. The most distinguished totem is the pig, for this creature stands next to man in rank, and those who have the pig as their totem are known as *malasie*. Each of the four main clans comprises several sub-clans, and this classification is, from the social outlook, almost more important than the main subdivision into clans, for the members of a sub-clan are accounted blood-relations who are all of equal rank and constitute the village unit of Trobriand society. Sexual intercourse between members of the same sub-clan is prohibited by taboos of varying stringency. The incest-taboo is especially strong, and the indigenes speak with the utmost horror of the possibility that brothers and sisters could ever copulate. Intercourse between the sexes is likewise forbidden in certain physiological conditions. Above all, a woman must not allow her husband's intimate embraces when she is pregnant or when she is suckling. Sexual intercourse is also proscribed in war-time, during overseas expeditions, when the

fields are being tilled, and at the time of certain magical ceremonies.

As we have already learned, one of the props of chieftainship is the privilege of polygamy. Polyandry, on the other hand, is absolutely forbidden. This is the only matter in which woman is less advantageously situated than man. The general equality of the sexes is most plainly disclosed in the performance of the magical rites which play a large part both in the public and in the private life of the Trobrianders.

When one of the wives of a chieftain dies, the community to which the deceased woman belongs places a girl at the disposal of the chief, or, if he be too old, at the disposal of his successor. The result of this practice is that an heir to the throne may already have several wives before the chief dies. When the latter's death occurs, his successor inherits all the widows, who automatically become the wives of the new chief, and whose children he has to adopt into his own household. When there is a heavy mortality among the chiefs, their widows may thus change husbands several times, so that a number of the wives of a young chief may be elderly women. However, no obligation is imposed upon him to have sexual relations with the wives bequeathed to him.

Family life among the Trobrianders is, in general, a most harmonious one. During the cool morning hours, the main occupations are agricultural; or the men go a-hunting and a-fishing while the women gather fruit, mussels, and crabs. When the man returns from the chase late in the afternoon, he takes a rest, but his wife attends to household matters. At eventide, the members of the family sit in front of the hut, the mother preparing food

while the children play under the father's guardianship, and while he cares for the latest addition to the family.

We now come to what chiefly interests us in the present work, the sexual relations of the Trobrianders.

When still comparatively young, the children are emancipated from parental control, and enjoy great independence. They form child-communities or groups, to which they belong from the fourth or fifth year of their age until puberty. They spend their days as best pleases them, sometimes with their parents, and sometimes in their own little republic. If it takes their fancy to go for a day's outing, they will tolerate no hindrance, whether from their parents or from the chief. This freedom extends to sexual matters. From their earliest days, in their homes, children are witnesses of their parents' sexual embraces, since the whole family is herded together in one room. Moreover, their elders talk openly about sexual matters in their presence. At the same early age they learn the tribal traditions, and are taught to pay respect to taboos.

Since the child-republics consist of both boys and girls, the young republicans have ample opportunity for practical initiation into the mysteries of sexual intercourse, and for furtively gratifying their mutual curiosity about the aspect and functions of the genital organs. Such childish indulgences are taken as a matter of course, no one objecting to mutual manipulations of the genitals or to mutual contact between genital organs and little mouths. Actual coitus begins as soon as the youthful organs are competent for this. Grown-ups see nothing to cavil at in such practices. "The children are playing at *kayta* (sexual intercourse)," say the parents with a

smile. However, this "playing *kayta*" must only be done in the forest. Such love-play on the part of children when in their parental homes is looked upon as improper. It is said that girls may be deflowered and possessed at the early age of four or five, but probably this is exceptional. Malinowski believes that, as a general rule, an active sexual life among the Trobrianders begins in girls between the ages of six and eight and in boys between the ages of ten and twelve. Many of the children's games display a sensual trend, but the youngsters are also at times inclined to invest their sexual pleasures with an imaginative glamour. They often play at house-building or at being father and mother in some other than the crudely sexual sense. In an out-of-the-way corner of the forest they will build one or more tiny huts, where they live as man and wife, prepare their own food—and, when they are able, copulate.

Sometimes, however, the sexes separate. Boys' groups and girls' groups are formed, the members of these seeking their amusements homosexually.

The adults let the children do as they please. It does not appear, however, that an adult man or an adult woman ever indulges in sexual practices with children. The Trobrianders would regard such a grown-up as little better than an idiot. It is, in fact, noteworthy that perversions such as are common in most civilised countries—homosexual practices between adults, sodomy, exhibitionism—are extremely rare in the Trobriand Islands. The island codes do not forbid these practices. They are not punishable offences, nor are they regarded as unwholesome. They would simply be looked upon as ludicrous and contemptible. A Trobriander who should have recourse to such pitiful substitutes for normal

intercourse would be believed incompetent for the gratification of his impulses in a natural way, and would be greatly mortified by such a suspicion. Custom allows male friends to walk about with their arms intertwined, and occasionally to share a sleeping-place. It seems probable, however, that homosexual relations between the members of such a pair are altogether exceptional, since the Trobrianders have a loathing for the bodily excretions.

At the age of about thirteen the boy becomes an adolescent. A little before this he will have begun to wear a fig-leaf or its tropical equivalent, while his little sister will have worn a short petticoat from the age of four or five. In the girls, adolescence is announced, as usual, by the appearance of menstruation, by the enlargement of the breasts, and by the growth of the axillary and pubic hair. The "fig-leaves" consist, in this case, of the leaves of pandanacea or of the areca palm. They are attached to a girdle, and cover no more than the pubic region and the back as high as the first lumbar vertebra. In addition, adults often wear an ornamental girdle, sometimes made of costly materials. Great care is always taken that the genital organs shall be covered by the fig-leaf. Except in the intimacies of the conjugal bedroom, it is laid aside by men only when they are fishing, or when they are bathing with other members of their own sex. In such circumstances, nudity is regarded as a matter of course, whereas at other times to uncover one's nakedness in public is looked upon as unseemly. The women's petticoats are made of banana-leaves, which are dried, dyed, and sewn together in narrow strips. Above the under-petticoat, a second petticoat or skirt is worn, but this is laid aside in the house, when among friends, and

when at work. The women are no less careful than the men in seeing to it that these primitive garments shall actually hide the parts whose exposure is regarded as improper.

This sense of shame that leads to the concealment of the external genital organs is, however, an acquirement of civilisation. It was not shame which led to the wearing of clothes, for the sequence was the other way, and shame itself arose out of the practice of being more or less clothed. Because certain parts of the body were habitually covered, the wearers of these early garments began to regard it as unseemly to reveal them to the public gaze. Robert Louis Stevenson, who passed the closing years of his life in the South Seas, records that in his day the women of the Gilbert Islands went about totally nude, with a graceful unconcern. The first, the most primitive article of clothing worn by the Polynesian women, the *ridi*, was not very well designed to conceal the pudendum. It consisted of a short petticoat or jersey made out of smoke-dried leaves of the cocoa-nut palm—leaves which, in this condition, look much like tarred strings. The lower end of the garment came only a little way down the thigh. Above, it was very inadequately attached, so that a single sneeze, one might fancy, would lead to complete exposure. Still, inadequate as the *ridi* was, to take it off in public was a grave offence against good manners.

Presumably what developed into a fig-leaf or apron was, among primitives, originally worn solely for decorative purposes. At the outset, it was only a string which concealed nothing, a cord such as is still worn round the hips by many natives in Africa and elsewhere. Subsequently ornamental articles of the most diversified kinds were fastened to this cord. Some of

them were pendent, and, without being designed for such a purpose, they accidentally concealed the genital organs. From this chance concealment there ultimately developed, one may suppose, the custom of covering the pudendum. We have direct evidence that shame cannot have been the original motive for the concealment of the reproductive organs. Even to-day, among many savage and semi-savage peoples, these organs, instead of being concealed, have attention drawn to them by a sort of " ornamental clothing ". For instance, among the Ostyaks, a people of Finnish stock in north-western Siberia, the women wear a decorative " loin-cloth " by means of which the genital region is outlined with beads. Widely diffused, too, among many primitives, is the custom of adorning the penis in one way or another. A penis-sheath or penis-case is worn. The article is often brightly coloured and is manifestly designed to direct attention to the penis. It will be remembered that I have already mentioned a vestige of this which was found in the representations of the male genital organ upon medieval armour; and students of costume are familiar with the braguette or cod-piece which was part of a man's breeches at a later period. Maybe the penis-sheath, the fig-leaf, and the cloth or its equivalent which the women of many native races wear between their thighs, had also a protective purpose. Women may well have been afraid lest, in the primitive forest, and especially when they were sleeping, various small creatures, such as ticks, would creep into their genital organs.

At adolescence, among primitives, the family community begins to break up. In accordance with a strict taboo, brothers and sisters must now be kept apart. The older

boys quit the home, lest their presence should disturb the sexual life of their parents. The adolescent male therefore transfers to the *bukumatula*, the bachelors' house, to dwell there in company with other adolescents or with widowers among his male relatives until his marriage. The daughters are placed under the guardianship of elderly widowed aunts or other female relatives on the maternal side.

At this age, what have hitherto been innocent, sportive, and childish erotic relationships, assume more serious forms, leading to passionate love-intimacies of shorter or longer duration. But the sexual inclinations have not yet become so strong as to lead the young folk to think of marriage. Both sexes will have a number of free amorous experiences before they think of entering into a permanent union with the duties it entails. Psychologically, as far as the sex life is concerned, there does not seem to be much difference between young Trobrianders and Europeans of like age. The young male islander hopes that his girl will be faithful to him, but he is by no means prepared to reciprocate!

The adolescents, like the children of a village community, form a small independent republic, or rather two republics, one of the lads and the other of the lasses. They lead a free, unrestrained, and happy Arcadian life. No serious obligations are as yet imposed upon them, although the taboos that regulate their conduct are more stringent than in the case of children, and they have to play a more active part in the affairs of the tribe. Already they begin to engage in agriculture, to hunt, to fish along the coast, and even to make longer voyages; but such activities are voluntary rather than compulsory. As soon as they have had enough of it, they can stop work.

The range of their love-adventures now expands. Young men and young women make excursions on which they can combine the joys of sexual intercourse with the pleasures of new scenes. Erotic relationships of an exogamic type begin. Whereas the children had to go into the forest for their sexual indulgences, a young man has sleeping quarters of his own in the bachelors' house, or he can use the hut of an unmarried relative. To some of the store-houses, too, there are rooms attached in which a young couple can settle for a time to enjoy pastoral intimacy. The transition from such casual dalliance to the more lasting unions which precede marriage is gradual. The love-relationships of young Trobrianders are in many respects akin to the trial marriages which are or were common among country-folk in many parts of Europe. Peasants of the Bregenzerwald region in Vorarlberg like to convince themselves of their reciprocal compatibility by such experimental unions. If no pregnancy results, the girl and the youth can separate without prejudice to the reputation of the former. Tarnish only results when a young woman has too many such experimental unions before settling down. (Compare Thomas Hardy's account of the "island custom" of Portland in *The Well-Beloved*.)

Among the Trobrianders trial-unions are, as a rule, of fairly long duration, but do not necessarily result in a lasting marriage. Either partner can dissolve the liaison at will. Nor, even while the intimacy continues, is the individual freedom of either partner restricted in more than a moderate degree. At certain festivals, boundless licence prevails, and on these occasions other young men and young women find it amusing to detach the partners

of a temporary union each from the other, and to make sure that one and the other of them shall find different partners for the nonce.

One of the most important orgiastic festivals, known as *kayasa*, is now (thanks to the influence of the missionaries) on the decline, being still celebrated only in a few of the villages to the south of the island of Vakuta.

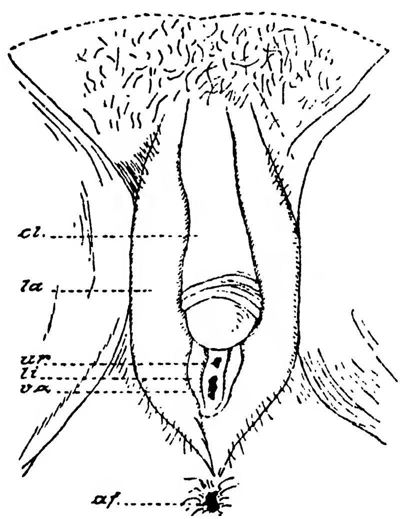


FIG. 73.—A WOMAN'S EXTERNAL GENITALS, SHOWING THE CLITORIS ENLARGED TO THE SIZE OF A SMALL PENIS.

cl, clitoris. *la*, labium majus. *ur*, urethral orifice. *li*, labium minus. *vo*, vaginal orifice. *af*, anal orifice.

During the *kayasa* a girl has the right of proposal, making her choice known to the man upon whom her desires are fixed by slapping him or by scratching him with her finger-nails. Nor do these natural weapons suffice. The girl will attack the object of her affection with a bamboo-knife, or with a small hatchet. Young men make it a point of pride, after such a night, to exhibit many wounds

as proofs of virility; and the female aggressors vie with one another in wounding as many men as possible, each of these victims possessing her as a reward for his stoicism. In our own land, of old, all restraints were loosened at fair-times and during the carnival; still more is this the case at a Trobriander *kayasa*. Sexual intercourse is effected publicly in the village square. Even married folk participate in the orgy, customary ties being loosened for the moment. A favourite sport at the *kayasa* is the tug-of-war, men against women, the victors, with loud yells, flinging themselves on the vanquished for sexual congress. Among the Trobrianders, as among many other native races, it is " good form " for a girl to spend the night with any man who may happen to be present in the village as a guest.

Apart from the great orgiastic festivals, there are other times at which free rein is given to the sexual impulse, and in this matter periodicity makes itself felt. There is always a sharp rise in the curve of amorousness at the full moon, and a climax is reached at harvest-time. It is then that the young men set forth upon " *ulatile* expeditions ", this meaning that they go by night in search of the beauties belonging to another village. If such an invader is caught in the act, the " rightful " lover of the girl and his mates will give the adventurer a sound drubbing. On the other hand the girls have a way of revenging themselves for unduly frequent " *ulatile* expeditions " on the part of their young men by combining upon a *katuyausi* or love-excursion. They begin by appointing a go-between, who settles day and hour with the lads of an adjoining village. Wearing their best petticoats, the girls slip out of their village to join the young men who

are waiting for them in the neighbourhood of the other village. Custom demands that, to begin with, the young men should leave the girls unmolested for a time, while their visitors (having no lip-stick) tint the lips with betel-nut, sing songs, and play an instrument resembling a jew's harp. At length, by singing a prearranged song, the girls announce that they are ready to receive their lovers. Soon all the young men of the village are sitting opposite the girls. Lads and lasses begin to chaff one another, and each young fellow chooses a girl. Custom demands that the initiative shall come from the hosts, and that every guest shall accede to a host's demand. The young fellow gives his chosen fair a present, the acceptance of which bestows on him the right to spend the night with her. Such love-excursions sometimes entail disagreeable consequences for the young beauties. They try to get home secretly, as they had set out. Often enough, however, they are surprised in the act of return, and chastised by their outraged lovers, each of whom then publicly and forcibly reasserts his right to the sexual possession of his own girl.

As previously explained, weeding in the fields is, among the Trobrianders, an essentially feminine task. It is regarded as unseemly, when women are thus engaged, for a man to approach them or to notice them in any way. Should such an indiscretion be committed, the women have the privilege of castigating him for his presumption, with the usual upshot of sexual excesses.

Still, these outbursts are exceptional. Generally speaking, a young man and a young woman who are living in trial-marriage are true to one another, or are at any rate discreet in their libertinage. Should either engage in

love-excursions to another village community, this must be done unofficially, and the pair are expected to maintain the amenities in daily life. Kicking over the traces must be achieved " respectably ", that is to say in secret.

The bachelors' house provides a loving couple with the possibility of long-lasting association. In these houses two or three or four pairs will live for a considerable time, not, as might be expected, in a sort of group-concubinage, but each pair apart. Every one of the young men has his own sleeping-bench, which he shares with his beloved, tribal custom prescribing upon every inhabitant of the bachelors' house a stricter attention to the rights of his fellow-inmates than he will pay anywhere else than beneath its roof.

The conventions must also be observed in the bachelors' house as regards the performance of the sexual act. A pair who want to couple will wait until the other inmates have gone to sleep, and will then effect coitus while lying down, since in this position their embraces are less noisy. The lovers recline on their sides face to face, at first pressing their thighs closely together. Then the woman throws her upper leg across the man, and simultaneously the penis is introduced.

Such an attitude is not the favourite one among the Trobrianders for coitus, being only adopted in the bachelors' house out of consideration for the other inmates. The customary position elsewhere is for the woman to lie on her back with her legs spread wide while the man kneels in front of her, so that her legs rest on his hips ; or he seizes her legs and draws her close to him. Even more often, the woman loops her legs over the man's arms, and supports herself as she

does so upon her elbows. Other positions are disfavoured. Above all, these natives regard as unpractical the position which is most usual for sexual intercourse in western lands, saying that thereby the woman is hampered in her movements and does not secure full gratification. " The man lies heavily on the woman, presses her down, so that she cannot collaborate." When the man squats on his haunches, they declare, he can move more freely, and there is nothing to hinder the woman in her reciprocal movements.

Among the Trobrianders, the man in sexual intercourse always has it in mind to secure full sexual gratification for the woman as well as for himself ; and since in women the coming of the orgasm is comparatively slow, he defers the climax for himself until his partner is ready. Among recent writers, Van de Velde has laid especial stress upon the difference in the course of the curve of sexual excitement in men and women respectively, and upon how important is a recognition of this physiological fact for the attainment of happiness in conjugal life. Before all, a woman with little or no previous sexual experience must gradually be aroused by preliminary love-play, so that detumescence may occur in her conjointly with the male. Failing this, the sexual act will not give her adequate satisfaction.

In human beings, as in the lower animals, the female (at any rate an inexperienced woman) is comparatively frigid, whereas the male is more impetuous, more passionate. A woman, however, is technically capable of intercourse at any time, without pleasurable sensation, whereas in a man a considerable degree of sexual excitement, manifesting itself in erection, is an indispensable

preliminary to the act. In a large proportion of instances, therefore, a woman, at the outset of her more intimate sexual experiences, has no bodily pleasure, and is likely to remain devoid of gratification if her partner continues to pay no heed to this difference between their respective sexual lives. In such circumstances, even though she loves her husband, sexual congress may remain or may become repulsive to her. A woman wants to be wooed, to be conquered by degrees; that is why the art of love, with its gradual progress from the finer to the coarser erotic advances, is of such decisive psychological importance. The primary physiological coldness of woman depends, according to Van de Velde, " upon the fact that a woman who enters for the first time upon an active sexual life learns only by slow degrees to experience sexual pleasure of such intensity as to be as eager for intercourse as is her sexual partner and therefore to demand its repetition. A further reason for the physiological coldness of women lies in this, that the arousing of excitement during the act of coitus in a woman without previous experience proceeds, as a rule, at a much slower tempo than in the male, with the result that, unless her husband makes allowance for this, she does not achieve an orgasm, for the climax is over and done with in his case before the stimuli she needs in order to reach a like climax have begun to take full effect."

In man, then, sexual excitement arises more quickly than in woman; but thereafter, when ejaculation is over, it subsides more quickly than in woman. Even though the occurrence of an orgasm in the woman is not essential to fertilisation and reproduction, there is ample experience to show that a vigorous orgasm makes a

woman much more likely to conceive. Were it only for this reason, a husband must be careful to avoid robbing his wife of sexual enjoyment by a selfishly brutal or maladroit procedure. As Van de Velde puts it, in a satisfactory marriage we do not have merely a man copulating with a woman, but an act of mutual intercourse.

Among the Trobrianders, preliminary love-play is considered of great importance, although this sport of love runs along different lines from those familiar to the children of civilisation. As among the Hindus, so among these islanders, the places suitable for love-play and the nature of the caresses are prescribed by tradition. Important, however, as these preliminaries are, they are not regarded as in themselves sufficient, being only looked upon as the necessary prelude to a complete act of physical union. Among certain other Melanesian stocks, on the other hand, who do not, like the Trobrianders, practise sexual intercourse without restraint from early youth, it is held that a betrothed couple should lie enjoying mutual caresses without proceeding to the sexual act. As far as these latter people are concerned, it still remains to be cleared up whether this restraint imposed upon young people is dependent upon a higher level of civilisation and perhaps upon moral objections to pre-conjugal sexual intercourse.

Despite the widespread belief among westerners that the kiss is a peculiarly western token of affection, in the Trobriand Islands, no less, this caress plays an important part in the preliminary sport of love, although the indigenes regard it as foolish and tedious to kiss for a long time as do the whites, pressing their mouths together. When a pair of lovers have found a suitable place in the

primeval forest or in the bachelors' house and have convinced themselves that they are not being spied upon, they spread a mat upon the ground or floor, the man lays aside his " fig-leaf " and the woman takes off her fibre petticoat. They sit down or lie down side by side, caressing one another with arms and legs. Then they come to the familiar rubbing of noses, also pressing cheek against cheek and mouth to mouth. As their mood grows more passionate, mouth and tongue assume leading rôles. Sometimes they bite one another's lips until the blood flows. The most passionately contrectative is the woman, whose affection finds vent above all in scratching her mate. The scratch-marks a man bears after such an encounter will be proudly displayed by him, just as will the marks of a sucking-kiss be shown off by a young fellow among ourselves.

Repugnant to European taste are the biting-off one another's eyelashes by the lovers, together with the mutual catching and devouring of head-lice. This last detail, however, is insisted upon with great emphasis by Malinowski, who was informed of it by his native friends.

Island custom forbids lovers to eat together before marriage. This would be as indecorous among the Trobrianders as it is among us for a man to enter the bedroom of a woman to whom he is not married—with the only difference that these " savages " observe their own conventions more faithfully than we do. The young people of the island never eat together in or in front of the bachelors' house, but each of them feeds separately with parents or other relatives. For a girl to take a meal in public with her lover is an official proclamation of marriage and has a binding ceremonial force.

When the lovers have come to the conclusion that they will suit one another as husband and wife, the time draws near when the girl's family, which has hitherto had no concern with these preliminary love-experiences, must take up a definite position with regard to the proposed marriage. The man's family has no concern with the matter. Strangely enough, the last word in the decision is left to the girl's father, although he is not legally regarded as her relative. The bridegroom tries to ingratiate himself with the family of his beloved. If he is successful, the father-in-law will say: "You have been sleeping with my girl? All right, then marry her." In other cases he will show his approval by asking the would-be husband for a trifling present. If, on the other hand, the girl's family is adverse to the proposed marriage and gives no sign of goodwill, the young man must take the initiative. Should the family persist in a refusal, then the couple may give up their intention and may separate; but in other instances the bride, defying opposition, will go to the parental home of her lover and will spend the whole day there, without, however, joining in a meal. Now the young man's relatives take action, offering the girl's parents a really valuable gift, whereupon as a rule the difficulties are smoothed away. Should they persist in their veto, the young people can do nothing; for, so long as the girl's relatives are stubbornly opposed to the marriage, the young couple have no claim upon them for food, and without their aid in this respect the attempted marriage would speedily break up.

Although, as previously explained, among the Trobrianders young people cohabit freely from childhood upwards, it is regarded as a disgrace for an unmarried

girl to become pregnant. The fact is, however, that "illegitimate children" are rarely born. Strange as it may seem, during the period of unrestrained sexual life which lasts from the first years of childhood until marriage, the girls are commonly sterile, and yet as soon as they marry they become pregnant, and frequently bear a number of children in succession. Malinowski insists that no preventive methods of intercourse are ever used by the islanders, who do not even dream that such practices exist. Since they are unaware that the male semen is a fertilising agent, there can be no question of coitus interruptus. One might be inclined to suppose that abortion must be freely practised, but Malinowski believes the contrary. If so, we are here faced by a physiological enigma. In this connection, however, it will be remembered that the prostitutes of western lands, who are continually having sexual intercourse with ever-changing partners, rarely become pregnant.

Speaking of prostitution, I should mention that this institution, so debasing to woman, is unknown among the Trobrianders. Malinowski's researches have thrown a strange light upon the sexual manners and customs of savages. Much of what he tells us may seem repulsive to those who are under the sway of the Christian tradition. We shall, however, attain to juster views by ridding our minds of conventional prejudices. These children of nature obey the biological laws of nature more candidly and more unrestrainedly than we do. All the same, they follow much more scrupulously than do civilised men and women the dictates of their own peculiar moral code. Finally, let me quote once more: "There is nothing either good or bad, but thinking makes it so."

BIBLIOGRAPHY

The following books, which themselves contain comprehensive bibliographical references, may be recommended to the reader who wishes to follow up the paths opened in the foregoing work :

HESSE, K., and DOFLEIN, F. : *Tierbau und Tierleben.*

MEISENHEIMER J. : *Geschlecht und Geschlechter im Tierreich.*

BREHMS : *Tierleben.*

BAUR, E. : *Einführung in die experimentelle Vererbungslehre.*

GOLDSCHMIDT, R. : *Einführung in die Vererbungswissenschaft.*

—— *Die sexuellen Zwischenstufen.*

HAECKER, VA. : *Allgemeine Vererbungslehre.*

MALINOWSKI, B. : *The Sexual Life of Savages.*

PLATE, L. : *Selektionsprinzip und Probleme der Artbildung.*

RADL, E. : *Geschichte der biologischen Theorien.*

THESING, C. : *Experimentelle Biologie.*

—— *Die Gesetze der Fortpflanzung.*

WINKLER, H. : *Verbreitung und Ursache der Parthenogenese.*

INDEX

Th. H. Van de Velde, M.D., in "Progress of Medicine" regarding the German edition of the present volume:

"Thesing knows the art of presenting biological phenomena in a manner readily understandable by the average educated person, and yet fascinating for the trained student of natural science . . . This book gives an insight into the gradual development of sexual mechanisms, and of a sex and love life; proceeding from the simplest organisms, through worms, snakes, spiders, dragon flies, crayfish, toads, frogs, fishes, birds, mammals, to primitive man. To this end, a profusion of highly interesting illustrations are presented, of animals of all kinds engaged in love-play, and in the act of copulation. Some of these illustrations are drawings, but most of them remarkable photographs. Whosoever finds delight in the creations of Nature will cherish this book."

Some Press Opinions Regarding the English Edition:

"One of the requisites of civilization is a biological and anthropological conscience. Dr. Thesing's book should help to develop it. This is an account of the mating instinct and

process throughout organic life. It is magnificently illustrated."

—"*The New Generation*"

"This book deals with just one aspect of the behavior of animals. Since this is an aspect which is generally concerned with the reproduction of the species, it is a study of fundamental importance. It is of especial value to the psychologist.

"In this book Dr. Thesing gives us plenty of data on the mating habits of all kinds of animals. It is a cliche to say that the study of animal psychology is in its infancy. At present we must go on collecting data, as Dr. Thesing is doing."

—"*Everyman*"

"This is a remarkable book, which gives an account of the sexual relations of all kinds of creatures, from the most primitive forms up to, and including man."

—"*Countryman*"